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MANUFACTURE OF WOVEN FABRICS.

THE patterns represented in the accompanying figures are intended to illustrate a variety of designs such as are produced by means of an arrangement employed by Messrs. D. Scott, of Manchester, and J. Edelston, of Preston. In these figured woven fabrics, the faces consist partly of cut pile and partly of damask, leno, or other figured pattern, or of all damask of weft-cut pile, or partly of damask and partly of plain cut pile, or of any combination of leno or other open-work with weft-cut pile.

For the production of these fabrics the inventors make use of a loom of the ordinary construction, but in which the tappets of the shedding-motion are arranged in the manner required for floating the weft-threads over the warp-threads, so as to form races in the parts of the pattern that are afterwards cut to form the pile. A Jacquard or other mechanism is employed to produce the damask, leno, or other figure that is being woven at the same time as the cut-pile portion of the pattern.

In some combinations of these weft-pile fabrics portions of the threads are thrown to the back of the cloth, which portions are afterwards sheared off or otherwise removed

Fig. 1 represents a design produced partly of weft-cut pile and partly of damask. The white stripes, A, A, show the weft-cut pile, which may be trod as tie-up No. 1, or any other similar weft-pile tie-up. The shaded stripes, B, B, show the damask figure, which may be any design within the scope of a Jacquard machine. The white in stripe B represents the plain ground in the figure, and the shaded part, the weft-thread floating over the warp, as in any ordinary Jacquard figure. C represents a crammed stripe or cord of warp-threads, which may or may not be introduced at the option of the designer. The whole of this design is worked by a Jacquard of the ordinary construction, with the warp drawn in in the usual way, or the damask figure may be worked by the Jacquard and plain weft-cut pile by shafts in addition to the Jacquard.

Fig. 2 represents the method of weaving a design made of a weft-cut pile with damask-cut pile. The white stripe at A shows the weft-cut pile, which may be trod in any of the ways named in the explanation of Fig. 1 The white in stripe B represents the damask of cut-pile, which may be trod as tie-up No. 1, or as any other weft-pile tie-up in which the race is preserved. The black in stripe B represents the plain ground, which is formed by throwing the pile picks on the back, or by interweaving them in the back. C represents a crammed stripe, as in Fig. 1. In the stripe, B, the weft-pile picks which are left on the surface of the cloth, are afterwards cut in the usual manner and stand up and form the figure of cut pile. The whole of the design may be worked in the same manner as No. 1 design.

Fig. 3 represents the method of weaving a figure of partly leno. The stripe at A shows the weft-cut pile, which may be trod in any of the ways named in explanation of Fig. 1, or it may consist of cut pile worked on the principle of the cut pile in Fig. 2. The horizontal lines at B show the leno picks; the perpendicular lines, the leno warp threads. The leno may be worked as tie-up No. 2, or as any other leno tie-up. In the leno the warp is drawn in in the usual way, either full-dented or empty-dented, according to the pattern required.

In tie-up No. 2, A, B, C, and D, represent four of the warp-ends which are worked by the Jacquard and are drawn through the harness; C and D are also drawn through the doups or other equivalents to form the intermediate portion of the leno. Nos. 1 to 20 represent the picks. When the picks are required to be on the back of the leno, all the warp must be lifted. This combination may or may not have the addition of a crammed stripe between the leno and the velvet, as in Fig. 1. When a number of picks are required to form the pile, it is necessary to throw a great portion of them to the back of the leno, which have afterwards to be sheared off or otherwise removed. The whole of this design may be worked by a Jacquard in addition to the requisite number of doups necessary to form the leno required; or a combination of cut pile and leno may be worked by shafts alone without a Jacquard.

Fig. 4 represents the method of weaving a combination of partly-cut pile and other work than leno. The stripe, A, shows the weft-cut pile, which may be trod in any of the ways named in explanation of Fig. 1; or it may be of damask of cut pile worked on the principle of that in Fig. 2. The horizontal lines at B show a portion of the weft picks, which, interwoven with the warp-threads, form the open-work; the perpendicular lines show the warp-threads. The warp is drawn in in the usual way, either full-dented or partially-dented, according to the pattern desired, and the open-work may be worked as tie-up No. 3, or any other open-work tie-up.

In tie-up No. 3, A, B, C, D, E, F, represent six of the warp-ends which are worked by means of the Jacquard. Nos. 1 to 6 represent the picks. When the picks are required to be on the back of the open-work, all the warp must be lifted. This combination may or may not have the addition of a crammed stripe between the open-work and the velvet, as in Fig. 1. In the same manner as in the previous designs, this one may be worked by means of an ordinary Jacquard or any other shedding-motion.

Figs. 5 and 6 represent the method of weaving weft-cut pile patterns distributed over the whole surface of the fabric. The white in the figures shows the damask of cut pile, which may be trod as tie-up No. 1, or as any other weft-pile tie-up in which the race is preserved. The black represents the plain ground, which is formed by throwing pile-picks on the back, or by interweaving them in the back. The weft-pile picks which are left on the surface of the cloth are afterwards cut in the usual manner, and stand up and form the figure of cut pile. The warp is drawn in in the usual way, and the whole of these two designs, or any designs within the scope of a Jacquard machine, may be worked by a Jacquard of the ordinary construction.

The patterns and tie-ups shown in the figures are only given as illustrations, and may be varied to any extent, according to the nature of the fabrics to be woven and the patterns to be produced.—*Universal Engineer.*

Tie Up No. 1.

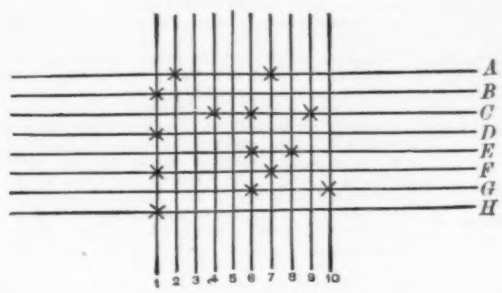
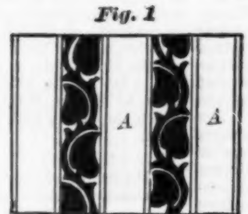
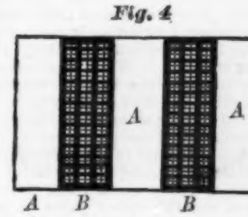


Fig. 1



A c B c B

Fig. 4



A B B

Tie Up No. 2.

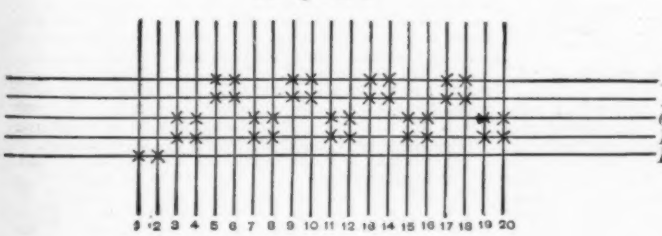
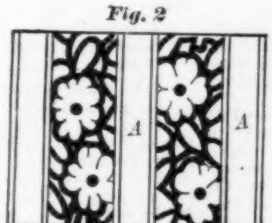


Fig. 2



A c B B

Fig. 5

Tie Up No. 3.

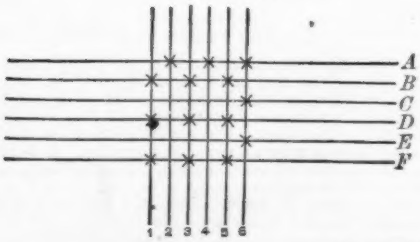
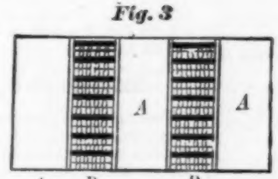
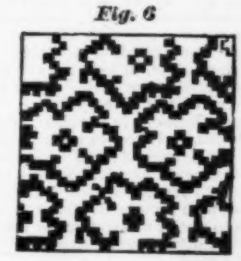


Fig. 3



A B B

Fig. 6



MANUFACTURE OF WOVEN FABRICS.

MANUFACTURE OF SHADE-COLORED YARNS AND FIGURED FABRICS.

A NEW process has been introduced by Mr. T. B. Gibson, of Glasgow, for manufacturing shaded thread or yarn, of cotton or linen, for producing the raised, figured, or shaded effects in embroidered fabrics, or for coloring the weft or warp parts of figured and fancy woven fabrics. It is also applicable to knitting and netting, such as figured-lace fabrics, shawls, and hosiery articles. By this means, the yarn, and the figured or fancy parts of the fabrics embroidered or woven therewith, have all the effect of ordinary shaded dye-colors, with a fixed color which does not wash out or spread, as the ordinary dye-colors of yarns do. The process consists in using the yarns in their original colors, as prepared in hanks or chains ready for bleaching or dyeing; the yarns, however, are only partially bleached in their bleaching liquids, the full depth of the original color being left at the

top of the hanks or loops, which are shaded off gradually by bleaching to within a short distance from the bottom of the hanks, where a part is left pure white. This new or improved shading of yarn may be done intermittently, that is, in two, three, or more divisions of the hanks, and changes of time in the bleaching process or action may be given to them by the intermittent or timely raising or lowering of the hanks out of or down into the bleaching liquids, by means of carrying-rods or frames placed over the vats and which are made movable for the purpose. Otherwise the frames may be made to rise or fall regularly by a constant or regulated motion imparted to them by motive-power gearing, so as to raise or lower all the hanks of yarns in this manner slowly and regularly out of or into the bleaching liquid. In either case, the time allowed within the bleaching liquor would be sufficient to gradually bleach out the original color in a shaded manner, from the full tone at the top to the half or quarter tones at the middle part of the hanks, and to a light cream and a pure white at the lower part as before stated. The yarn may be thus shaded as in the present hand process, by scutching or shaking the hanks loose, and hanging them on their rods carried over the vat which contains the bleaching-lime liquor; then, by the dipping process, the lowest sections or parts of the hanks required to be perfectly white are dipped into and below the surface of the liquor, which must be of such a strength at the commencement as to bleach this immersed part completely white; the lime liquor is then reduced in strength, so as to have a less bleaching effect in the second or higher part of the hank, which is then lowered below the surface of the liquor, so as to give a creamy shade of color to these parts of the hanks; and so on, the reduced strength of the liquor leaving an increased depth of tone or color towards the top of the hanks, which, never being allowed to reach the liquor, retain the full depth of their original or natural color. But when this shading effect is to be produced on the hanks by the reverse process of immersing them to the full depth desired at first, then the liquor is made weakest at first, and gradually strengthened as the hanks are raised out of the liquor, so as to lighten the shade to the creamy and pure white near the lower end of the hanks, until they finally become quite white at the end. After this shade-bleaching, the lime and bleaching matter are washed out of the bleached parts of the yarn, which are then treated with diluted sulphuric acid, and afterward washed in hot and cold water in order to completely remove the chemicals, as in ordinary bleaching. The yarn is then dried and made ready for being cut into proper lengths, or is wound on to spools or pirns for use as thread for embroidering, or otherwise as weft or warp for weaving. When desired, the hanks or loops of this new shaded yarn may be washed occasionally at the times of changing during the process of bleaching, in order to stop the further action of the bleaching liquid in the parts of the hanks lifted out of the vats; or the hanks or loops of yarn, when lifted out of the bleaching liquor, may be drawn between tight gripping rollers, which press out the bleaching liquors, and prevent them from rising by capillary attraction into the upper parts of the yarn which are not desired to be bleached, or are already sufficiently bleached. This shaded or pattern yarn may be made in any length of hanks or loops, to suit the size of the figures or the particular fancy effect or fabric desired to be worked or woven.

GELATINE PLATES IN THE STUDIO.

By FRANK P. MOFFAT.*

IN reading a paper before you to-night, I do it more with the object of promoting a discussion on the present all-absorbing topic to photographers of gelatine plates than in the hope of being able to impart any new information on the subject.

Gelatine and collodion plates differ so entirely that I do not think it possible to use them satisfactorily together. In the first place, two dark rooms are required, but of course that is not an insurmountable objection. Secondly, the exposures are so widely different, and do not always bear the same relative proportion to each other. I mean that on a bright day a collodion plate will be more rapid, in proportion to a gelatine one, than it would be on a dull day. I think the whole secret of success in gelatine plates lies in the correct exposure, with which one must be very exact, because when it consists of three seconds, one extra second more or less makes a very great difference; and, if gelatine and collodion were being used promiscuously together, the difference in the exposure would be very apt to get one into a complete mess. Lastly, the appearance and requisite density of gelatine negatives after they are fixed are so entirely different from collodion ones that it would be most difficult, if not impossible, to have the eye trained to judge negatives by both processes at once. I will now briefly describe the way I expose and develop a plate.

Before placing it in the slide, dust it lightly with a camel's-hair brush. When exposing, be very careful that the camera is light-tight; and to insure its being so I always cover it completely with the dark cloth, allowing it to cover the lens as far as the slit for the diaphragm. I always develop with pyro, as it allows a margin in development; that is to say, if a negative be under-exposed, begin with a small quantity of pyro, and a large quantity of ammonia, and *vice versa*.

The developing formula I use is as follows,

Liquor ammonia	1 ounce,
Bromide of potassium	1 drachm,
Water	2 ounces,

which solution is kept in a dropping-bottle. When about to develop a half-plate, place it in an ebonite tray half filled with water. Put about three grains of dry pyro into a two-ounce cup and fill up with water. Throw away the water in which the plate is steeping, and pour on the pyro solution, then put into the cup eight drops of the ammonia-bromide solution, bring the pyrogallic solution back into the cup, and then pour the mixed solutions on to the plate again, when, if correctly exposed, the image will appear rapidly. Should the high lights come up out of proportion to the shadows, drop some more of the ammonia-bromide into the cup, pour back the solution from the developing tray, and again flow over the negative. This can be done several times until the shadows are quite out; but one must always bear in mind that one extra drop to begin with is worth five after the image has begun to appear. On the other hand, if the image come up flat and over-exposed in appearance, pour away the solution and dissolve some fresh pyro, only adding two or three drops of ammonia, which will cause the high lights to attain the proper amount of density without over-developing the shadows. I, immediately after pouring the developer over the plate, take a camel's-hair brush, which should be kept soaking in a dish of clean water near the developing trough, and gently brush the plate all over, which removes any air-bells or dirt which may be on the plate. To get clean negatives one requires to use a brush at all stages before placing in the slide, while developing, after washing, and before varnishing. This causes very little trouble, and tends greatly to the cleanliness of the negatives. After the plate is developed and washed, place it in a strong solution of alum for a minute, then wash and place in the hypo, where it ought to remain for a quarter of an hour. Now wash it thoroughly under the tap, and place it in running water for one hour; then wash under the tap again, this time using a brush, sweeping it lightly over the surface of the plate. This takes away all traces of hypo, should any remain, and clears away any dirt which may have adhered to it while in the running water.

Should a plate begin to frill—which sometimes happens when washing, after taking it out of the hypo, owing to its not having remained long enough in the alum—at once place it in a dish of methylated spirits, and allow it to remain a few minutes; then, without further washing, place it in a rack, and wash it after it is dry.

The great difficulty in working gelatine plates is to judge, while developing, the proper density. If the plate be correctly exposed the requisite density is obtained when the image appears faintly on the back of the plate; but if it be in the least under or over exposed, this guide is of no use. One old photographic amateur told me he could never see the image at all, so he always counted a certain number while developing, and then washed the developer off. This would be a very good plan if you were always sure of the exposure, but, for my part, I prefer to see what I am doing. It is only by practice one is enabled to judge the proper density. The time the solution has been on the plate must be taken into account; for the longer the solution remains on the plate the denser it will be. If a negative come up dense quickly, although it may appear denser than another which has undergone a prolonged development, it will come down in the hypo very much more.

However, should a negative be found too dense when dry, place it in a dish of water and allow it to soak for at least an hour; if not properly soaked it is apt to reduce unevenly. After soaking, place it in a dish containing a weak solution of perchloride of iron of the color of pale sherry, and let it lie there until sufficiently reduced, when, of course, it requires to be washed. It should not be rocked at all while in the perchloride, as that has a tendency to reduce the shadows without the high lights, and causes it to become worse than it was at first. To intensify a thin negative I use a formula given by Messrs. Wratten and Wainwright in the pamphlet which they issue with their plates. The following is a copy of it:

"A.

Protosulphate of iron	15 grains.
Gelatino-acetic acid solution (as described below)	40 drops.
Water	1 ounce.

"B.

Nitrate of silver	10 grains.
Glacial acetic acid	10 drops.
Water	1 ounce.

"The gelatino-acetic acid solution is compounded as under:

Gelatine	15 grains.
Glacial acetic acid	3 drachms.
Water	5 "

"It is as well to prepare a stock of this, and also of 'A,' as they are both better for keeping.

"First flood the plate with water, and then with a solution of iodine and iodide of potassium of the color of pale sherry for one minute; rinse it off and apply enough of 'A' to cover the plate for the same time. Now drop into the cup a drachm of 'B,' and bring the 'A' back from the plate to the cup to mix them together. Re-apply, and keep moving over the surface until density is sufficient. If any air-bells should occur they must be kept moving, and then they will do no harm."

That is their formula, and I have only one thing to add, which is that the plate must be thoroughly well washed under the tap, after it has been intensified, until all signs of greasiness disappears; otherwise the film has a tendency to become of a mottled appearance.

All I have said to-night has been written over and over again in the journals and elsewhere, but I must excuse myself on the plea that I have really nothing better to bring before you.

* Read before the Edinburgh Photographic Society.

BEAUMONT COMPRESSED AIR-ENGINE.

THE value of compressed air as a motive power has long been recognized, and many attempts to utilize it in this respect have been made, although hitherto they have not always been attended with practical success. The main difficulty which has stood in the way of inventors and has retarded the progress of the air-engine has been that of providing means whereby the full power contained in the air under compression can be utilized economically and at serviceable pressures. Judging from the results of some experimental runs made with an air-driven locomotive which we recently attended, this difficulty would now appear to have been mastered, and highly-compressed air to have been rendered practicably available as a source of motive power. This has been effected by Col. Beaumont, R.E., in an engine which has been lately running in the Royal Arsenal, Woolwich, where its powers have been put to the test of practical work. It is now some four years since Colonel Beaumont first commenced experimenting in this direction, and he has proceeded step by step, improving and perfecting as he went on, until he has at last succeeded in producing the engine in question. The construction of this engine is based upon the principle of utilizing the entire power stored up in compressed air, no matter how high the pressure may be. This is effected by admitting the air into successive cylinders, having different areas, commencing with the smallest, and in making provision by which as the pressure falls in the reservoir the consumption of air can be increased. In other words, the elasticity and the expansive properties of air are taken full advantage of in this engine, just in the same way as the corresponding properties in the vapor of steam are utilized in the compound steam-engine—that is, in each case the gases are expanded from the smaller and high-pressure cylinders into the larger and low-pressure cylinders.

In appearance the engine necessarily differs from an ordinary locomotive, the absence of a funnel or other outlet for smoke or steam being the most prominent point of departure. The machine, which is noiseless, more or less resembles a large tank carried upon wheels, with sundry levers and handles on the top, where the driver is placed. The engine in question, however, is not of the form which is to be adopted in practice, but it is that in which the principle has been finally developed, and is now being demonstrated. The air is first compressed by a stationary engine and machinery into the reservoir of the air-engine. In the present instance the compression is effected by the machinery in the arsenal, by permission of the authorities, who have also consented to Col. Beaumont carrying out his experiments there, seeing that the principle will find an important application in several directions connected with the Government, notably in that of electrically-steered torpedoes. The air is stored in the reservoir under a pressure of 1,000 lb. per square inch, and is delivered thence into the first and smallest cylinder at that pressure. After use there it is expanded into the second and third cylinders in succession, each cylinder having an increased cubical capacity in relation to the one preceding it. From the third cylinder, having there given out its last pound of useful effect, the air is ejected noiselessly into the atmosphere from a small port at the side of the cylinder. The first cylinder being of comparatively small area, difficulty might be experienced in starting the engine on a rising gradient or in the presence of other resistances. To meet this point there is an arrangement for admitting the air at full pressure into the second or intermediate cylinder, so that greater power is thus developed at the first stroke. Another difficulty invariably present when highly-compressed air is expanded, is the extreme cold produced, which, as is well known, is so great that the moisture in the atmosphere becomes condensed and frozen upon the working parts, thereby contributing to reduce the power and efficiency of the machine, and in time to stop its action. This difficulty is met in Col. Beaumont's engine by the application of heat, externally, to the compressed air. This is effected by means of a diminutive steam generator, which is carried on the framing of the engine. So effectual is this application of a mild heat that the expanded air issues from the exhaust ports quite warm.

With this engine we lately made several runs with very satisfactory results, the machine working smoothly, noiselessly, and at good speed. A number of runs were effected over a straight length of that part of the Arsenal railway which runs direct from the proof butts to the Plumstead entrance of the Arsenal, the length traversed being nearly 700 yards. At starting the gauge showed a pressure of 1,000 lb. per square inch in the air reservoir, and at stopping this had become reduced to 620 lb., thus showing that only 180 lb. of pressure had been consumed in the runs, which in the aggregate amounted to a little over three miles. The engine weighs $10\frac{1}{2}$ tons, and a truck containing several passengers which it hauled, weighed about $1\frac{1}{2}$ ton more, making a total of 12 tons. The result of the runs, however, was not considered so good as had been obtained upon previous occasions, as a number of stops were made in order to test the controlling and other qualities of the engine. The engine is arranged so as to be able to make a run of 20 miles with one charge of compressed air. What it really has done, we are informed, has been to haul a gross load of 22 tons for a distance of 11 miles, and the lighter load of 12 tons for over 20 miles, with one charge of air, and which it did under the observation of the Arsenal authorities. From these experiments it was deduced that the engine will take three tons one mile with the expenditure of one cubic foot of compressed air. There can be no doubt that the engine, so far, has worked most satisfactorily, and there can be as little doubt that the new pattern engine, which we understand will soon be running on the Edinburgh and Portobello tramway, will prove as successful. If cost of production, maintenance, and working is found to be low, other things being equal, there is a wide future before this system. Not only will it be applicable for tramway service, in which connection it has been mainly developed by Col. Beaumont, but it will probably be found capable of working the traffic of our underground railways. This would be a great boon both to the railway passengers and to the company's servants. It will be seen that this system of applying compressed air differs from any that has been hitherto in use, inasmuch as it avoids the loss entailed by the use of a reducing valve and the cooling of the air by expansion. The arrangement appears to enable a much greater amount of power to be realized out of a given quantity of energy stored up than hitherto, and the success of the system, so far, entitles it to the consideration of those who are connected with our tramways and railways.—*London Times.*

LIQUID FUELS FOR STEAM ENGINES.

RECENT experiments on the Long Island Railroad with naphtha fuel have been regarded in some quarters as indicating the displacement of coal and the substitution of naphtha in the production of heat and the generation of motive power. The apparatus used was the Holland hydro-carbon retort, a patented invention. It is of cast iron, and consists of four chambers, two for water and two for coal oil or naphtha. A fire is first started to generate about ten pounds of steam. Then the hot water is allowed to run from the boiler into the generator, and is converted into superheated steam, which is brought in contact with the gas flame generated from the coal oil, and decomposed. The oxygen of the water, being liberated from the hydrogen, is at once taken up by the carbon flame, its combustion is made perfect, and the hydrogen is left free to burn by combustion with the free oxygen of the air which surrounds it, producing an oxy-hydro-carbon flame or heat of great intensity. The inflow of oil and water by the four separate induct pipes into the four separate chambers of the retort is controlled by four valves, which the fireman can govern as easily as an ordinary stop-cock.

It is claimed that this invention will save not only in the cost of fuel, but also avoid the annoyance of smoke, cinders, and the odors of sulphurous gases. In one experiment a forty-ton locomotive and one car, with fifty passengers, after the fires were lighted and everything in readiness, ran twelve miles with a consumption of three gallons of naphtha at three cents a gallon, using only two of the four chambers in the retort. The inventor claims that, with his apparatus, locomotive power can be furnished at from one-half to one-third the present cost; that it can be applied to ordinary engines by alterations, to cooking stoves, etc.

Mr. Edward N. Dickerson, the well-known patent lawyer, recently made some interesting statements in conversation relative to this invention. He said: "The manner in which this apparatus works is that naphtha or some liquid hydrocarbon is burned in association with steam. The result of it is to decompose the steam and set free the gases that compose it—hydrogen and oxygen. As a consequence, there is

a very perfect combustion of the naphtha. But all calculation of the saving by the use of naphtha as fuel must be delusive when based on the present price of naphtha. At present naphtha is cheap because it is too volatile to be used for domestic purposes. But if it can be used for this purpose the price of it must go up, and consequently the relative cost of it, as compared with other fuel, will change. It is obtained by the refining of petroleum, and is now regarded as a sort of waste product. But if it is to be used in all the locomotives in the country, it must be so much in demand as to greatly increase its price. So much for the question of economy. As to the saving from the absence of smoke and cinders, that is true enough; but the naphtha must be used with great caution. Its use would undoubtedly save labor in the handling of coal and cinders. Hydrogen, of course, is the best possible fuel, because it has greater heating power than any other substance. But in getting hydrogen from water, as the Holland retort does, according to all theory it cost as much power to decompose the water to get the hydrogen as the heat is worth when you burn the hydrogen thus obtained. If you decompose a pound of water and get hydrogen out of it, and burn that hydrogen in the air, the result must be that pound of water over again. That is a sort of swapping jack-knives that does not pay as a practical result in the production of power. But the combustion of naphtha is made very perfect by this decomposition and recomposition of the water, and that is the reason, if any, why this process is valuable. It is not because there is any more heat to be got out of the hydrogen when it burns than it costs to decompose it. If you could do that you would have perpetual motion; but the profit comes in burning the naphtha to better advantage. I have no doubt that the value of the process is in the hydrogen that is mingled with the carbon to make naphtha. It is not the hydrogen of the water. The action of the water is auxiliary, but it is not itself a profitable source of heat, in my judgment. Some very wild statements have been made in connection with the experiments with this invention as to the usual results of combustion, it having been asserted that in burning coal in an ordinary locomotive boiler only eight per cent. of the heat of the carbon combustion goes into steam and ninety-two per cent. is lost. That is not true at all. In point of fact, with the most perfect combustion, one pound of carbon would, theoretically, evaporate something less than fourteen pounds of water. Now, good boilers will evaporate about nine pounds of water to one of carbon. So that in place of a loss of ninety-two per cent. you are, in fact, losing only the difference between nine and fourteen, or say thirty-five per cent., which is the loss of escaping by the chimney, heat, radiation, etc.

"The only way you can utilize the entire value of any fuel is by burning in a calorimeter. But when you have furnaces and a chimney you must lose heat. When carbon-monoxide escapes out of a chimney it takes up another atom of oxygen from the air and burns. In this new method of getting heat one of the merits is the perfect combustion of the carbon and hydrogen that is in the fuel. The losses of heat that take place in a boiler will be encountered to almost as great an extent in any form of fuel. That is to say, if you can get out of coal the evaporation of nine pounds of water to one of carbon, you will not get a very much greater amount of evaporation in proportion if you burn this liquid fuel. The great losses are not in the combustion of the fuel, but mainly in the use of the steam after you have got it. The best steam engine of to-day gives no more than ten per cent. of the value of the heat that is expended in the furnace; but the greater part of this loss of ninety per cent. is due to circumstances that are in no way connected with the combustion, but are entirely independent of it. Say, for instance, that your fire is burning at a temperature of 3,000°; whether you are burning naphtha or coal, you are turning that into steam which is not more than 350°. Practically, you can't use steam of greater heat and pressure. Here is an enormous loss between the temperature of the combustion and the temperature of the steam. The total power in a steam engine and boiler is the difference between the temperature of combustion and the temperature of the steam when it is thrown away or ceases to be used. You may compare heat to a contracted or compressed spring. Its potentiality depends upon its temperature, just as the potentiality of the spring depends upon how much it is compressed. When you let go the spring its power decreases. So there is a great fall of heat or power between the 3,000° and 300°—between the furnace and the boiler. There is a tremendous fall of temperature that gives no power, but is wasted; whereas, if you could get your steam as hot as your fire, or nearly as hot, the power would be enormous. Superheated steam does not mean steam of a particular temperature. Steam may be superheated that is not hot enough to burn your head. Superheated steam merely means steam that is hotter than the water out of which it arises. Saturated steam means steam that is of the same temperature as the water out of which it comes; and it may be red hot or ice cold. Steam at the freezing point presses about one-tenth of a pound to the square inch. You could run a steam engine with a lump of ice for a boiler. The steam engines of Watt were run on what engineers call a vacuum—that is, with steam made from water below the boiling point if exposed to the air, say at 180° or so. Ice is 491° hot. In fact, ice is very hot as compared with absolute cold, which is 491° below the freezing point. A lump of ice in an atmospheric vacuum will make steam one-tenth of a pound pressure to the square inch.

"There is no increase in the pressure of steam by superheating it as long as it remains in the presence of the water out of which it comes. The use of superheating steam is to preserve the heat that has already been expended upon the water suspended in it in the form of spray. If a boiler of water is 212°, then there is about 1,154° of heat in the steam. If you heat water from 60° to 212° in a given time, it will take the same fire six times as long to boil it away. It does not get hotter. Suppose we could carry steam in a boiler at the temperature of 600°, you would have steam up to over 1,000 pounds pressure to the square inch. What an enormous uncoil of the spring that would be if you let it go down from 1,000 pounds to the square inch to equilibrium! That shows the enormous value of heat. But there are no materials that would stand such heat and pressure in use. No engine using it could be kept tight, and I suppose that practically 400° is as high as steam can be used. Now, since one great loss comes from the vast difference between the temperature of combustion and the temperature of the steam in the boiler, that has got to be the result, whether you use hydro-carbon fuel or coal. The new invention, therefore, does not pretend to overcome one of the greatest losses of power in our present steam engines. There is very little difference between the amount of heat necessary to evaporate water at a high pressure and that which is required to evaporate water at a low pressure. Practically, it does not require any more heat to boil water at a pressure of 200 pounds to the square inch than it does at 15. Dr. Black and Watt thought there was no difference, but a French physicist discovered that there is a difference of about 30° in 1,200. It is, therefore, of much more advantage to evaporate water at a high pressure, because you have got your steam compressed, or so much more spring in it. The water should be evaporated at the highest pressure consistent with holding it in the boiler. To the same extent that you fail to get the heat in your boiler that you have in your furnace you are losing the elastic power of steam, or its capacity to expand. This value of expansion in steam was for a long time unrecognized. The United States Government had a fleet of vessels built in utter defiance of the value of the expansion of steam. Now that value is universally recognized. One after another the steamship companies have come to recognize it. Even the staid conservative Cunarders had to come to it. The English use the compound engines, but those engines derive their advantage from the expansion of the steam in their cylinders. They do not, however, carry expansion far enough to take much advantage of the principle of the compound engine; and it is true to-day that a single cylinder, with a proper valve gear, will give more power for a pound of coal than any of the compound engines in use. A compound engine, however, is the best engine if properly constructed and used, but not the best when used for the purpose of expanding steam only eight times, as they now use them; and it is demonstrable that if they would throw away half their cylinders they would have better engines. The great problem has always been to use the steam economically after it was made. Compared with that great problem which is not touched by the use of liquid fuel, the proposed substitution of naphtha for coal is of slight importance.

"The law is that one cubic inch of water turned into steam will lift a ton a foot high. That is God's law. How are you going to get more? You must utilize another of God's laws, that steam under great pressure is elastic and will uncoil itself down to the last gasp. That is the law which makes it expand after it has got into the engine, and it will push the piston and expand down, down, until it comes into equilibrium. The hotter you can have it when you start the more power you can get in it to use by expansion. If you can expand it ten times, then you have got three tons and a third weight lifted a foot high with each cubic inch of water evaporated, as against one ton when there is no expansion. One hundred expansions will give you five and six-tenths tons lifted a foot high, as against one ton without expansion.

"The best engine of to-day gives only ten per cent. of the value of combustion in power. Possibly three per cent. more might be saved by combustion, but this is the limit, which would add thirty per cent. to the power of a given weight of fuel. I do not see how so much could be saved; but, theoretically, it is possible. After that is done, then only thirteen per cent. of the power of the fuel is utilized, and any further saving must be done by expansion of the steam. By the proper use of expansion twenty-five per cent. of the power of combustion can be utilized, and the cost of fuel can be reduced to less than one-half of the present cost with the best engines now in use. This, in my opinion, is very easily done, and when it is done steamers will cross the ocean between Sundays with much less expense than they incur now. But there is no use making a boiler carry more steam unless you are going to expand down. You may just as well carry low pressure unless you expand. The present materials limit the pressure to about 200 pounds to the square inch. Beyond that the materials get burned up, and it is not necessary to carry more pressure than boilers now do in order to reduce the cost to less than half of the best results now got. At present the engines that are doing the best work are expanding seven or eight times. They begin with steam at about 80 pounds pressure to the square inch and let it go at about 10 pounds. The best engines at present produce a horse power with the cost of 2¼ pounds of coal an hour. The same power may be had by the use of ¾ of a pound of coal an hour.

"The use of coal oil or liquid hydro-carbon as a fuel is by no means new. There are many patents on it. Inventions were patented twenty years ago containing all the essential principles. There are thirty or more of them. They are generally patents of some peculiar mechanical arrangement for burning the coal oil to advantage. That appears to be the nature of Mr. Holland's invention, so far as I can judge from a casual and cursory examination. The principle of it has long been recognized as good, and if the price of naphtha could be kept at a standstill the relative saving of fuel could be calculated, but not otherwise. As for running a forty-ton engine with one car twelve miles on three gallons of fuel, there is no particular proof in that, because a locomotive may be run that distance without any fuel, simply by charging the boiler with steam before you start. The proper test of such an invention would be to burn a weighed quantity of naphtha of known composition in the apparatus proposed, and ascertain how much water it would evaporate. A comparison of the actual evaporation with the known calorific power of the fuel would show how perfect the combustion was, and what proportion of the heat was saved by the apparatus and turned into steam. If a larger percentage of the calorific power was saved than is saved in the combustion of coal in a good boiler, then one of the facts necessary to be known is settled; and a comparison of cost between the two sorts of fuel would settle the money question, provided always that the cost of naphtha could be foreseen when it came to take the place of coal for all these purposes. This coal-oil fuel invention is now so old that some of the patents have expired, and yet not much has been done with it. That makes me wonder. Every now and then somebody gets excited and puts money in it. But, as I have said, there is no essential principle in it that is not twenty years old. I have no doubt, however, that there may be some advantage in some of these new methods of applying the old principles.

"Dr. Holland may have some details that are better than others, and I hope he has, and that his plans will enable him to supersede coal, so far as naphtha can do it. But there is nothing new in the idea of burning naphtha with superheated steam and air, and locomotives have been run with some of the apparatus invented by others for this purpose, and also stationary boilers for driving engines in New York and elsewhere. Why they did not succeed I do not know; nor does the fact that they ceased the use of the fuel prove that it cannot be used with advantage at the present price of naphtha, or at a higher price. Among others of the many patents on this subject look at page 661, vol. i., of Patent Office Reports of 1863, and you will find the following:

"'G. B. Hill, of New York, N. Y. Improvement in the means of using hydro-carbon oils as fuel. Patent dated Sept 15, 1863. The steam and hydro-carbon are conducted to a mixing chamber, in which they are mingled, and from which they pass to radiating pipes and through orifices, where they are ignited under the boiler. In starting, steam is obtained from a supplementary boiler, afterward from the main boiler, being superheated in the pipe as it passes to the mixer, and the hydro-carbon is vaporized in its passage to the same chamber.'

"This patent expires in September, and it shows a very good apparatus for the purpose of decomposing superheated steam with naphtha and burning the products in the air. There are many others of later dates, among which some are better, on the same principle.

"In my opinion, the best way to supply fuel for houses is to distribute hydrogen in pipes, the same as street gas is now distributed, which can be done now at a cost not much greater than coal, all things considered, and which in the near future will be done. Then the hottest fire can be had in an instant, and extinguished when it has done its work. It would pay to use it, even at a greater money cost, in the saving of dirt and the annoyance of ashes."—*N. Y. Sun.*

THE ST. GOTHARD TUNNEL.

AN unexpected obstacle to the early use of the St. Gothard Tunnel has been encountered, and one that may involve an entire reconstruction of a considerable part of the tunnel, or rather the cutting of a new section in the heart of the mountain. In that part of the tunnel where it was cut through a porous white stone the vaulting has already given way twice or three times, and it has required the greatest care and constant staying with timber to prevent the passage thereabouts from completely collapsing. It was thought, however, that a granite wall six feet thick would support the superincumbent mass of white stone and keep the tunnel permanently open. A wall of this thickness has just been finished, but it has begun to give way, and the engineers are at their wits' end how to overcome the difficulty.

INFLUENCE OF PISTON SPEED ON THE FRICTIONAL AND AIR RESISTANCES OF AN UNLOADED STEAM ENGINE AND ITS CONNECTED LINES OF SHAFTING IN A FACTORY OR MACHINE SHOP.

By Chief Engineer ISHERWOOD, U. S. Navy.

THE writer having occasion, during some experiments conducted by him in the machine shop of the New York Navy Yard, to know the power consumed in overcoming the friction of its unloaded engine, and in overcoming the resistance of the unloaded numerous and long lines of shafting with their drums and belts driven by that engine, made, for the two cases, the determination hereinafter stated of the mean indicated pressures on the steam piston required to give it different speeds varying from 15 to 70 double strokes per minute, both inclusive, and increasing by five double strokes at a time.

The engine experimented with had one horizontal, direct action, non-condensing cylinder, driving a shaft which carried a fly-wheel of 15 feet diameter and 9 inches face, and a drum of 7 feet diameter and 30 inches face. A leather belt, 30 inches wide and 60 feet long, connected this drum with the lines of the machine shop shafting. The following are the dimensions of the steam piston used:

Diameter of the piston	20 inches.
Diameter of the piston rod	3¼ inches.
Net area of the piston, exclusive of its rod,	309·35 sq. in.
Stroke of the piston	40 inches.

When the experiments were made with the main belt thrown off, the steam pressure on the piston being exerted in overcoming only the resistance of the engine *per se*, that resistance was composed of the friction proper, and of the resistance of the air to the moving parts of the engine. The air resistance was due to displacement resistance and to surface resistance; the former being its resistance to the moving crosshead, connecting rod, arms of the fly-wheel, arms of the drum, etc.; and the latter being the resistance to the peripheral surfaces of the piston rod, connecting rod, shaft, fly-wheel, drum, etc.

When the experiments were made with the main belt in action upon the main drum, and driving the various lines of unloaded machine shop shafting together with their drums and connecting belts, the resistance to the steam pressure on the piston in addition to the above was that due to the peripheral surfaces of these lines of shafting and their drums, to the surfaces of their connecting belts, and to the air displacement by the arms of the drums, etc.

By deducting the steam pressure on the piston required to give it the experimental speeds in the first case from the pressure required to give it the same speeds in the second case, the remainders will be the pressures required to drive the machine shop shafting *per se*.

In such determinations the air resistance is generally included with the friction resistance proper, the whole being attributed to the latter. And, when the experiments are made with an unloaded engine alone, whose moving parts move slowly and are of great weight comparably with their surfaces, no error of practical value is thereby made. But, in the case of the lines of shafting, the air resistance becomes a very important constituent of the total resistance, for these lines being geared up to an extremely high speed, and having very extensive surfaces relatively to weight in their shafts, drums, and belts, the resistance of the air increasing in the ratio of the square of the velocity of the shafting, while that of the friction remains constant, a velocity is practicable with which the air resistance may equal or exceed that of the friction. The current of air created by the face surfaces of fly-wheels and belts is so strongly sensible that the most careless observer cannot fail to be impressed with the power consumed in its production.

In order not to interfere with the regular work of the machine shop, and thus make the experiments without cost, advantage was taken of short favorable occasions, at different times, so that the experiments were not all made during the same day; portions of four days were consumed, but at no great intervals apart.

Two carefully tested indicators, with scales of 16 pounds per square inch per inch, were employed, one at each end of the cylinder, and the motion for them was taken direct from the engine crosshead by means of a long and stiff wooden lever centered upon the wall of the engine house. For each speed of piston, five indicator diagrams were taken from each end of the cylinder, and the mean of the pressures from the whole ten was taken as the true piston pressure for that speed.

During the experiments the journals of all the shafting were lubricated from oil cups of excellent construction, delivering the same quantity of oil per revolution of the

shafts. The best sperm oil was used, and no change whatever was made in the manner of lubrication during all the experiments, which was exactly the same as when the engine was doing its regular work with 58 double strokes of the piston per minute.

Although the oil cups were arranged to *deliver* the same quantity of oil *to* the journals per revolution, it does not follow that the same quantity was *received by* them, the tendency being that after a rotary speed was obtained at which the centrifugal force was large in proportion to the gravity of the oil, less and less of the latter went on the journals as their speed became higher and higher. If such was the case, the lubrication at the higher rates of speed was less than at the lower rates. As regards the engine journals, this could not have much effect, as their speed of revolution at the highest was within the limits of easy lubrication; but, as regards the journals of the lines of machine shop shafting, the case was very different, their rotary velocity at the highest being exceedingly great, as they were very much geared up. At very high rotary speeds, the writer, in some late experiments on the value of different lubricants, found much difficulty in getting any oil to flow from the cups upon the journals, the centrifugal action keeping back the liquid in the cup, although the feeding was satisfactory enough when the speed was sufficiently reduced to allow the gravity of the oil to overcome the centrifugal action imparted by the rotation of the journals. He was obliged in these cases to mechanically force the oil out of the cup upon the journal by means of a loaded piston.

The experimental results will be found in the following tables, numbered 1, 2, 3, and 4.

TABLE No. 1, showing the resistance of the engine, *per se*, at the experimental speeds of piston; the main belt being removed from the main drum and the engine worked unloaded.

Indicated steam pressure on the piston, in p'nds per square inch.	Number of double strokes made per minute by the st'm piston. (Revolutions of engine shaft.)	Indicated steam pressure on the piston, in p'nds per square inch.	Number of double strokes made per minute by the st'm piston. (Revolutions of engine shaft.)
2·022	15	1·894	40
2·013	20	2·194	45
1·613	25	2·095	50
1·706	30	2·335	55
1·942	35	2·048	60

A simple inspection of the above Table, No. 1, shows that the piston pressure was the same for all the speeds of piston, the discrepancies being irregular, following no law, and very slight absolutely. Trifling inequalities in the friction of the indicator pistons easily account for the differences. The mean of the determinations for the ten different and widely varying speeds of piston is 1·9862 pounds per square inch of piston for the friction resistance of the engine, *per se*.

TABLE No. 2, showing the combined resistance of the machine shop lines of shafting, and of the engine, *per se*, at different speeds of piston; the main belt being in action on the main drum, but with all the tools disconnected and no work being done.

Indicated steam pressure on the piston, in p'nds per square inch.	Number of double strokes made per minute by the st'm piston. (Revolutions of engine shaft.)	Indicated steam pressure on the piston, in p'nds per square inch.	Number of double strokes made per minute by the st'm piston. (Revolutions of engine shaft.)
4·596	15	5·032	45
4·500	20	5·225	50
4·458	25	5·925	55
4·732	30	5·826	60
4·856	35	6·388	65
4·956	40	6·268	70

In the above Table, No. 2, the resistance appears to be constant from 15 to 25 double strokes of piston per minute; but from 25 double strokes upward there is a continual increase in the resistance, due to the causes hereinbefore stated. This increase, though marked, is irregular, owing doubtless to inequalities in the friction of the indicator piston, and to other causes impossible to eliminate or even discover in such experiments. It is highly probable that if the mean steam pressure had been obtained from a greater number of indicator diagrams for each speed of piston, more regularity would have been found.

In the following Table, No. 3, are the results in Tables Nos. 1 and 2 corrected, that is to say, the friction resistance from Table No. 1, of the engine, *per se*, is taken at the constant 1·986 pounds per square inch of piston for all speeds of piston. The resistances in Table No. 2 are corrected by taking a straight base line and laying off on it as abscissæ, by scale, the number of double strokes made by the piston per minute; next, on right-angled ordinates to the base erected at the ends of these abscissæ, laying off, by scale, the experimental resistances in pounds per square inch of piston, and drawing a fair curve through the free ends of the ordinates, leaving as many ends on one side of the curve as on the other, and at the same distances; finally, measuring, by scale, from the base line to the curve on each ordinate for the corrected resistance at the corresponding speed of piston.

The experimental results under the actual experimental conditions are valuable in showing the practical effect of increasing the piston speed on the pressure required to overcome the resistance of the unloaded shafting. This is the point of interest for factories, machine shops, etc., and the experiments show that, owing to the causes hereinbefore stated, this pressure increases in some power of the piston speed, instead of being independent of it and therefore constant at all speeds, as would be the case were the resistance purely frictional. Of course, each factory or machine shop constitutes a distinct problem and requires a separate solution. No general law can be given other than the qualitative one, that the pressure to overcome the resistance of unloaded shafting increases in some ratio of the piston speed. The experimental results also show that the resistance of the unloaded engine apart from the shafting, which resistance is almost one of pure friction, is constant and independent of the piston speed.

TABLE No. 3, showing the corrected results of the experiments for ascertaining the separate resistances of the engine, *per se*, and of the machine shop lines of shafting, *per se*, at different speeds of piston.

Number of double strokes made per minute by the st'm piston.	Indicated steam pressure on the piston, in p'nds per square inch, required to w'rk the engine, *per se*.	Indicated steam pressure on the piston, in p'nds per square inch, required to w'rk both the engine and the unloaded shafting.	Indicated steam pressure on the piston, in p'nds per square inch, required to w'rk the lines of shafting, *per se*.
15	1·986	4·500	2·514
20	1·986	4·537	2·551
25	1 986	4·594	2·608
30	1·986	4·677	2·691
35	1·986	4·781	2·795
40	1·986	4·922	2·936
45	1·.86	5·094	3·108
50	1·986	5·302	3·316
55	1·986	5·552	3·566
60	1·986	5·823	3·837
65	1·986	6·146	4·160
70	1 986	6·469	4·483

The resistance of an unloaded engine and its connected shafting is a *passive resistance* which can be overcome only by an expenditure of power; and as it must be overcome before the engine can move, the pressure equilibrating it must, in the case of a loaded engine, be first deducted from the pressure on the piston shown by an indicator diagram, leaving the remainder for the net pressure applied to the crank pin. The overcoming of this *passive resistance* involves a very serious loss of useful effect, and as the portion of the indicated pressure applied to the crank pin is the only portion available for external work or commercially valuable, the same engine, kept at constant speed, will work more and more economically the more and more it is loaded; hence the principal advantage of using higher and higher mean indicated pressures on the piston; but this advantage grows less and less with each increment of indicated pressure, because the constant pressure required to equilibrate the friction of the unloaded engine and shafting becomes a less and less proportion of the indicated pressure the more the latter is increased. Practically, too, there is the loss due to more heat radiation and to greater steam leakage with each increase of the mean indicated pressure.

In order to appreciate the amount of power absorbed by the resistance of the unloaded engine and shafting of the machine shop of the New York Navy Yard, the following Table, No. 4, has been calculated for the experimental speeds of piston and for the corrected indicated steam pressures on it in Table No. 3. The horses-power thus expended are given separately for the engine, *per se*, and for the shafting, *per se*.

TABLE No. 4, showing the horses-power expended in overcoming the resistance of the engine, *per se*, and of the shafting, *per se*, at the different experimental speeds of piston and for the corrected steam pressures on it in Table No. 3.

Number of double strokes made per minute by the st'm piston.	Horses-power expended in overcoming the resistance of the engine, *per se*.	Horses-power expended in overcoming the resistance of the shafting, *per se*.	Aggregate horses-power expended in overcoming the resistances of the unloaded engine and shafting.
15	1·8617	2·3567	4·2184
20	2·4823	3·1885	5·6708
25	3·1029	4·0747	7·1776
30	3·7235	5·0452	8·7687
35	4·3440	6·1136	10·4576
40	4·9646	7·3394	12·3040
45	5·5852	8·7405	14·3257
50	6·2058	10·3617	16·5675
55	6·8263	12·2571	19·0834
60	7·4469	14·3876	21·8345
65	8·0675	16·8986	24·9661
70	8·6880	19·6116	28·2996

The power expended in overcoming friction reproduces its calorific equivalent in the rubbing surfaces. For a long time all held the belief, still held by many, that the heat produced by the friction of one solid upon another was due to abrasion of the material, or rupture of its cohesion; an idea plausibly sustained by the fact that the smoother and harder a surface was, and the better lubricated it was by an unctuous liquid, the less was its friction when moving under pressure, and the less also was the abrasion of the material. But this explanation is directly refuted by another fact, of which the world long remained in ignorance, namely, that the friction between the molecules of liquids develops heat in absolutely the same manner as the friction between the surfaces of solids, while it is evident that in the case of liquids there can be no abrasion of material. In fact, abrasion diminishes rather than increases the development of heat by the rubbing together of two surfaces.

When a body undergoes friction, its molecules are mechanically thrown by the rubbing pressure into increased vibration, their resistance to which is what is known as the resistance of friction, and is directly proportional to the pressure producing the increased vibration. The heat developed by the friction being the result of, is also directly proportional to, the increased molecular vibrations, and, consequently, is directly proportional to the pressure producing them. There can be no other law of friction than this simple one of the direct proportionality of its resistance and of the heat generated by it, to the moving pressure which causes it, and all properly conducted and intelligently interpreted experiments sustain that fact. Hence the powers required to overcome the friction due to a given pressure, moving at different velocities upon a given surface, are directly as the velocities. And the powers required to overcome the friction due to different pressures moving at the same velocity, upon the same surface, are directly as the pressures.

The effect of liquid unguents is diminishing the friction of solid rubbing substances between which they are interposed, is due to the fact that liquids oppose less resistance to increase of molecular vibration than solids. With perfect lubrication, the solids never come in contact, but they nevertheless undergo some friction. The increased molecular vibration is primarily given to the liquid alone, which then communicates a portion of it to the solids. The popular idea that if the solid rubbing surfaces be kept apart by a liquid unguent they will experience no friction is fallacious. Their friction in that case will, indeed, be a practical minimum, and very slight in comparison with what it would be with the surface in contact; but it will exist, and show its existence, in the fact of different solids having different coefficents of friction, with the same unguents under pressures less than those necessary to produce contact, and with surfaces of the same degree of smoothness. The different friction coefficients of different solid substances, in the same condition as regards sufficient quantity of the same lubricant to prevent contact, pressure per square inch and smoothness of surface, are due to the difference of their resistances to increase of molecular vibration; in this respect, one substance being much better than another for practical use.—*Jour. Franklin Institute.*

EXCAVATORS AT CALAIS HARBOR.

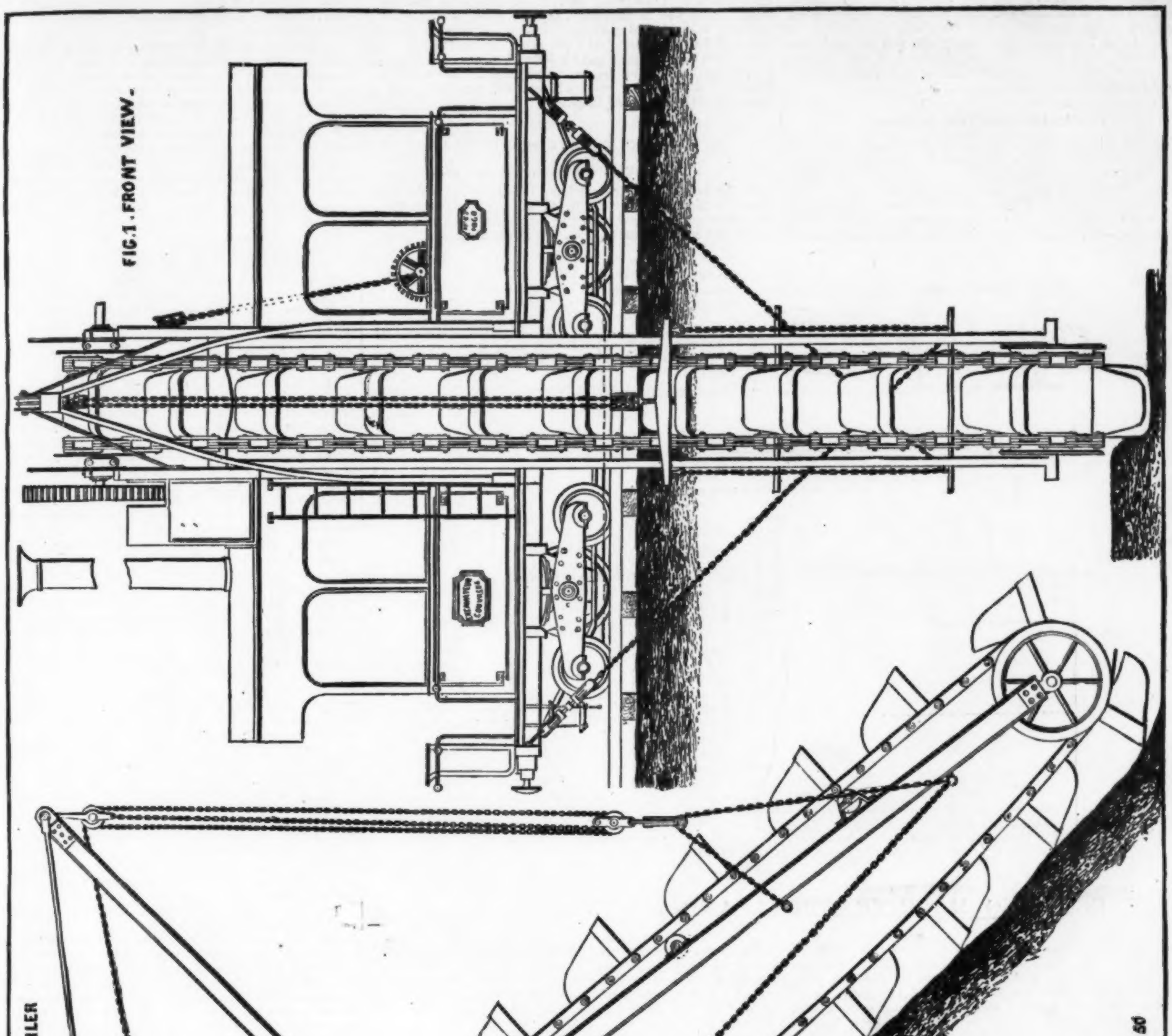
WE illustrate opposite an excavator much employed on public works in France. It was the invention of M. Couvreux, by whom a patent was obtained for it in 1860, and since that date various minor improvements have been made in it. It comprises a truck with wrought iron frame, carried on three axles with wheels placed to the 4 ft. 8½ in. gauge. The axles are prolonged at one end about 20 in., and carry a balance beam with the two wheels, which run on a third rail parallel with the others. These wheels constitute the extra support to the apparatus which is required when at work, and for traveling they are removed so as to run on an ordinary railway. These wheels are of wrought iron with steel tires, it being necessary that they should be capable of withstanding the heavy strains brought upon them when the excavator is at work. Steam is provided by tubular boilers with 420 square feet of heating surface, and tested to 8 atmospheres. The bucket chain is worked by two inclined engines of 10-horse power each, and the movement of translation is effected by a small separate engine, which also serves to raise the outer arm of the excavator. The latter is of wrought iron, about 33 ft. in length, and with it a depth of from 14 ft. 6 in. to 15 ft. 6 in. can be worked, the angle of the cutting being generally not more than 45°. A nearer approach to a vertical cutting can of course be made, but it is seldom advisable, as the outer wheels are but about 18 in. from the edge of the cutting, and as these carry a heavy weight it would often be dangerous to make a sharp cutting. The gearing is of cast iron, but with steel pinions. The buckets are of sheet iron, but provided with a steel nosing. The links of the chain are of steel, and the sockets carrying the gudgeons are riveted to a steel frame, the gudgeons themselves being of iron. Those parts of the drum over which the buckets work are of steel, to resist the wear of the chain. The buckets, it will be seen from the detail drawing, are hinged at the top, the bottom opening as the bucket reaches the top roller, and thus projecting the excavated material into the shoot, which directs it into the wagons standing next the machine. Each bucket holds 6 cubic feet. The boilers are fed from a tank opposite to the bucket arm, and to which it acts as a counterpoise. A sort of wagon for coal is also attached, which also serves as a small store and workshop for convenience of repairs, and affords some accommodation for the attendant.

The roller by which the chain is driven makes about 80 revolutions per minute, and thus presents 30 buckets to their work; so that the capacity of the machine is 180 cubic feet per minute, or 10,800 cubic feet per hour, or about 129,600 cubic feet per day of twelve hours. From this has to be deducted 3,990 for stops, change of wagons, etc., reducing it to 125,690 cubic feet, or 4,655 cubic yards per day of twelve hours. The quantity of work done, however, depends upon the material acted upon.

The whole machine weighs about 45 tons. It is employed for other work besides that of making cuttings and excavations. It may be worked in a previously formed trench for leveling the adjoining ground to a certain evel, and it is also used for loading up ballast into trucks for making embankments. In 1869–75, during the execution of the works for the regulation of the Danube at Vienna by M. Couvreux in conjunction with MM. Castor and Hersent, five of these excavators were used, and in 2,925 days of work removed 3,461,835 cubic meters, or 45,003,860 cubic yards of material. The Couvreux excavators are now employed at the new Port of Calais by the contractors, MM. Varinot, Caville et Cie. They are excavating from 11 ft. to 13 ft. in depth in fine sand, but to work that part of the sand which was under water dams and pumps had to be resorted to, as each bucket retained but a very small quantity of sand. Some modifications in the form of the buckets got over this difficulty, but for such work it would have been thought that Reeves's pneumatic excavator would have been employed. From carefully kept records it seems that the excavators at Calais have been removing, on an average obtained over 505 days of working, 751·6 cubic yards of sand covered with water, and 1443·75 yards of dry sand and ordinary material. The period taken into account is from June, 1877, to October, 1879. The total cost per day is made up as follows:

	Francs.
1 Driver	10
" Stoker	5
" " (night)	4
" Foreman laborer	5
2 Laborers directing and packing material into wagons, and	
14 Laborers to attend to and take up and relay the rails, etc., etc.	49
Coal, 1,600 kilo. (3,527 lb.) at 35f. per 1,000 kilo. (2,205 lb.)	56
Water	0·32
Oil	5·50
Grease	2·20
Waste or rags	1·80
Repairs and renewals	35·00
Total cost per day of ten hours, and for 1180·4 cubic yards	181·82
Or per cubic yard $\frac{181·82}{908}$ =	0·154 or
Taking a franc as 9·6d. =	1·47d.

The cost of water mentioned in the above is the nominal sum imposed by the town, the supply of water being really gratuitously provided. It would have cost at least 6f. per day to pump it. It is, moreover, calculated that if men and horses had to be provided to regulate and shunt trucks as part of the cost of excavation, an extra charge would have to be made, though three or four of the laborers above included would not be so wanted. The extra cost would

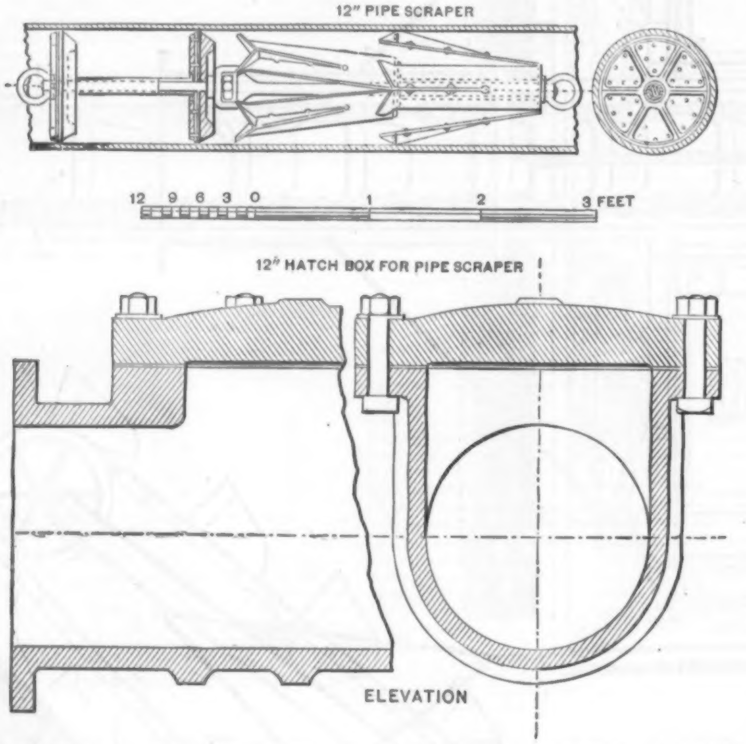


EXCAVATORS EMPLOYED ON THE CALAIS HARBOR WORKS.

then make the total = 1·69d. per cubic yard of material raised. The actual average cost per cubic meter when employed on the excavations for the Paris Exhibition, on the Gaud and Terneuzen Canal, Belgium, and at Calais, has been 0·193f., or 1·425d. We are indebted to the *Annales des Travaux Publics* for our illustrations and particulars of these excavators.—*The Engineer.*

CLEANING WATER MAINS.

THE following account of the use of the scraper, which we illustrate herewith, is taken from a report on cleaning water mains, which was presented, in February last, to the chairman and directors of the Consett Waterworks Company, by Mr. Edward Dodds, of Western Hill, Durham, by whom the work was carried out. The scraper is that of the Glenfield Ironworks Company, Kilmarnock. Mr. Dodds, having received instructions to clean the 12 inch water main from the Smiddy Shore Reservoir to the company's offices at Consett, a distance of over five miles, walked over the route of pipe, and found places where the pipes descend the steep banks to and across water courses, ascending the opposite banks. At these places there are quick bends, and in their locality a good many repairs had been done, in some cases the joints were very crooked and badly made. Scraping operations were begun on the 17th of January, at Honey Hill, the junction of 18 inch and 12 inch mains. The 12 inch pipe was cut for the purpose of fixing the hatchbox, illustrated herewith, in which is inserted the scraper. The pipe was found to be very foul, being reduced 1 inch in diameter by deposit on the inner surface of the pipe. The machine was placed in the main on the morning of the 18th, and passed to Horsleyhope, a distance of about one mile, in seven minutes, carrying with it to the outlet an immense quantity of deposit, described by the man told off at this point as resembling a huge black pudding, which continued to pass out of the pipe in a compact mass for over one minute; some lead was also carried by the machine and delivered here. Hatchbox No. 2 was then fixed, and the scraper put into the main to make the run of the Deane from the west to the east side. This length the machine passed in four minutes; a large quantity of lead and deposit was carried to this point.



SCRAPING MACHINE FOR CLEANING WATER MAINS.

No more hatchboxes being to hand the pipe was made good, and the machine again inserted at hatchbox No. 2, west side of Horsleyhope Deane, with the intention of making the next run to the cemetery at Castleside. The machine was started here, and after traveling about half the distance came in contact with a heavy piece of lead, which had run through the joint when making repairs. The machine was broken at this point, and the piston rod and one piston was left in the main, the scraper and the other piston traveled to the outlet, carrying with it a large quantity of deposit and the lead, which weighed 38 lb. Another scraper was then put into the main and started on the next run to the outlet on the second bank east of Stanniforda, *via* Consett Park. After traveling over one mile it stopped at a back flap box fixed in main, near to the burn which crosses the road at Stanniforda—the existence of which was not known. The orifice of this box was only 9 inches, therefore the piston of machine could not pass it, although the scrapers had; this was taken out and made good with a length of 12 inch pipe. The machine was again started and traveled to the outlet named, carrying with it a miscellaneous lot of material, viz.: one wagon sprag, one spade, two handspikes, and a quantity of deposit and lead.

The next run was to the drift at Consett Ironworks, where the greatest weight of *débris* and lead was carried to the outlet. The machine afterwards passed through the main, a distance of nearly six miles, in forty-seven minutes. The whole length of the main was found to be in an exceedingly foul state from deposit on the inside of the pipes, which so reduced its capacity that since the completion of the work the increased daily delivery is 500,000 gallons. The coating of the pipes remains good, and is apparently done in accordance with Dr. Angus Smith's specification. Mr. Dodds advises that the scraper should be put through the whole length of the mains through which there is a clear way every two or three years.

The same machines have been most successfully used at Oswestry, Elgin, Portmadoc, Lancaster, Aberdeen, Llanelly, Padiham, and Welshpool. Mr. E. B. Smith, in making a report on its use in Oswestry, says: "Before scraping, the delivery was 226,903 gallons per diem; it is now 350,308 gallons," being a gain of 54·4 per cent. "At Torquay," he adds, "the first scraping gave a gain of 34 per cent., though it eventually rose after repeated scrapings to 123 per cent." The cost at Torquay was £77 8s. 4d. per mile, and at Oswestry £21 10s.—*The Engineer.*

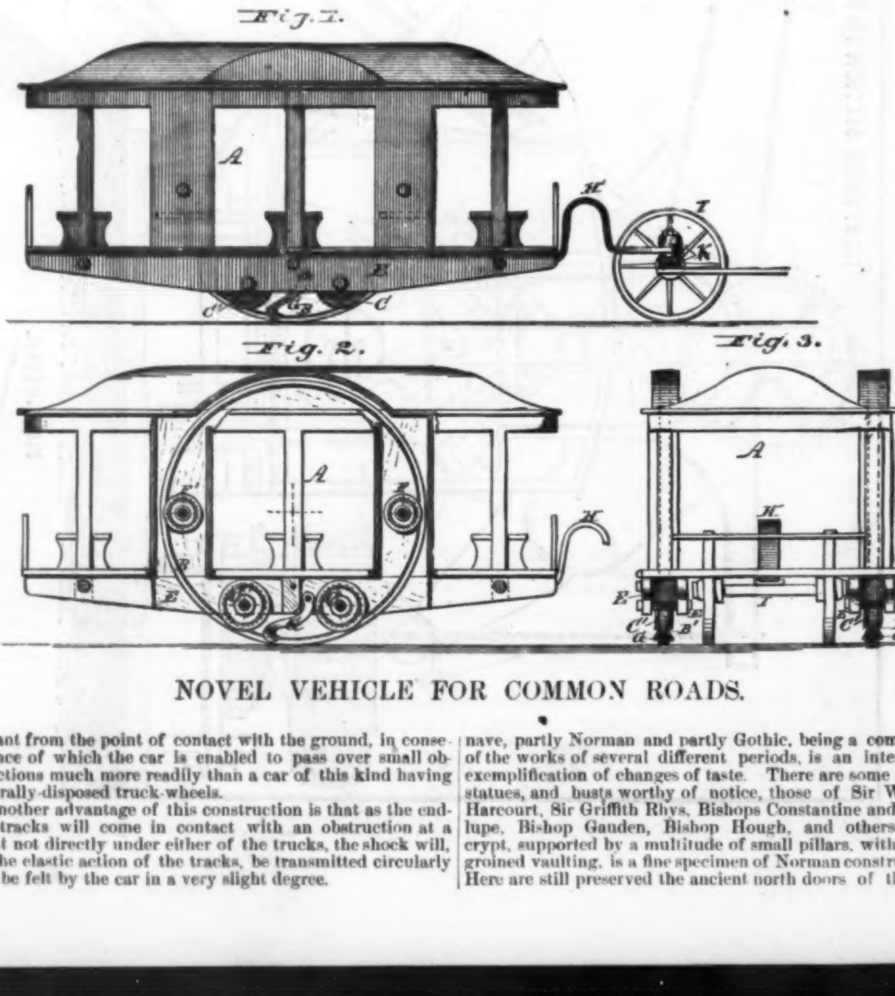
NEW VEHICLE FOR COMMON ROADS.

By TREAT T. PROSSER, Chicago, Ill.

IN the accompanying drawings, Figure 1 is a side elevation of a car having my improved scraper. Fig. 2 is also a side elevation, portions of the wood being broken away to expose the interior parts. Fig. 3 is a rear elevation.

The body, A, of the car is mounted centrally, so as to balance it as nearly as possible upon the large drive-wheels, B and B', which receive the weight of the car from the two sets of truck-wheels, C C', arranged to run on the interior surface of said drive-wheels, near their points of contact with the ground.

The drive-wheels are mere rings or circular tracks. The truck-wheels, C C', are journaled in suitable bearings in the side sills, E, of the car-body. They are placed some distance apart, on opposite sides of a vertical line drawn through the center of the endless tracks, thus bringing the weight of the car upon the endless tracks at two points equidistant from the point of contact with the ground, in consequence of which the car is enabled to pass over small obstructions much more readily than a car of this kind having centrally-disposed truck-wheels.



NOVEL VEHICLE FOR COMMON ROADS.

Another advantage of this construction is that as the endless tracks will come in contact with an obstruction at a point not directly under either of the trucks, the shock will, by the elastic action of the tracks, be transmitted circularly and be felt by the car in a very slight degree.

The wheels, C C', have a flanged tread to partially encompass the drive-wheels or circular tracks, so as to keep the latter in position.

Scrapers, G, are applied to keep the drive-wheels, and consequently the truck-wheels, free of mud and dirt. These scrapers consist of pendent arms loosely pivoted at their upper ends to the frame-work of the car, their lower ends being adapted to partially encompass the endless tracks between the points at which said tracks come in contact with the ground and the rear truck-wheels.

It will be seen that by this arrangement mud or dirt that would otherwise collect on the endless tracks and be carried up to the rear truck-wheels will be scraped off, thereby avoiding all danger of clogging said truck-wheels.

As this car is to be used on common roads, the advantage of these scrapers must at once be seen, for unless they are used, or some provision made of a like nature, the mud and dirt accumulating on the endless tracks would be carried up to the rear truck-wheels, and so choke or clog them that they would soon stop all motion, and thus prevent the smooth and even running of the endless tracks, which is of such great importance in using a conveyance of this description.

WORCESTER CATHEDRAL.

THE respectable little city of Worcester, on the banks of the Severn, has many remarkable associations with events of English history, from the Norman and the Plantagenet reigns to the Civil Wars of the seventeenth century, when it was thrice besieged, in 1642, in 1646, and in 1651, holding for the King against the Parliament. The defeat of Charles II. at Worcester upon the last mentioned occasion, was the achievement by which Cromwell was enabled to gain dictatorial power over England, and to proceed to the conquest of Scotland and Ireland. Our present business is only with the ecclesiastical edifice that forms the subject of a large engraving printed on the following page. The history of Worcester Cathedral need not detain us long in this place, though it contains the tomb of King John, whose body was brought hither from Newark upon his death in October, 1216, and that of Prince Arthur, the eldest son of King Henry VII., the Prince having died at Ludlow Castle in April, 1602. Worcester, called by the Saxons Wigornaceaster, was constituted a bishop's see in the year 680; having previously, with the dioceses of Hereford, Lichfield, Leicester, and Lindsey or South Lincolnshire, been ruled by one prelate, whose jurisdiction extended over the whole midland kingdom of Mercia. Among the notable bishops of Worcester in different historic ages, some of them holding this see together with another bishopric or archbishopric, were St. Dunstan, from 957 to 961; Oswald, founder of a Benedictine monastery here; Wulfstan, founder of the Cathedral under William the Conqueror and William Rufus; Walter Cantilupe, a vigorous champion of English laws and liberties against Henry III., and equally against the Pope; Godfrey Giffard, Chancellor of England later in that reign; and further on, the sturdy Protestant Hugh Latimer, a great church reformer, popular preacher, and martyr at Oxford in Queen Mary's time; Stillingfleet, a polemical theologian of the reign of Charles II.; Hough, the ex-president of Magdalene College, Oxford, whose case partly brought about the Revolution of 1688; and Hurd, a scholarly writer of the Georgian era.

The sacred building is not the finest of its class, and has some features of architectural interest. There are remains of Bishop Wulfstan's Norman structure in the crypt beneath the choir, and other Norman work in the nave and the main transept. The choir and its aisles, with the Lady chapel, are early English, begun in 1224, and with some general resemblance to the choir of Salisbury Cathedral, in the style ascribed to St. Hugh of Lincoln. In this choir stands the tomb of King John, with his stone effigy on the top of it; that of Prince Arthur is in a chantry, of late Gothic style, much decorated, on the south side of the high altar. The choir has been restored, during the last twenty years, by Mr. Perkins, architect to the Dean and Chapter. The nave, partly Norman and partly Gothic, being a compound of the works of several different periods, is an interesting exemplification of changes of taste. There are some tombs, statues, and busts worthy of notice, those of Sir William Harcourt, Sir Griffith Rhys, Bishops Constantine and Cantilupe, Bishop Gauden, Bishop Hough, and others. The crypt, supported by a multitude of small pillars, with richly groined vaulting, is a fine specimen of Norman construction. Here are still preserved the ancient north doors of the ori-

WORCESTER CATHEDRAL. DRAWN BY S. READ.

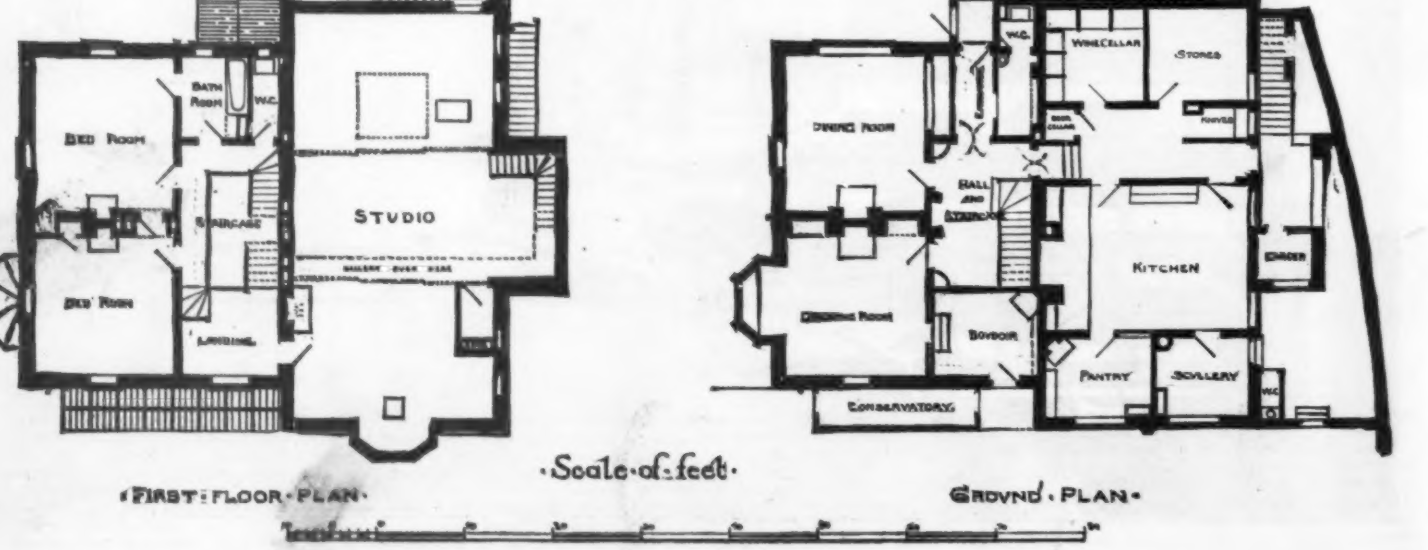
ginal cathedral. A horrid story is told by the old chroniclers, that once upon a time, in the darkest of dark ages, a man who stole the bell from the altar was flayed alive for his crime of sacrilege; and that his skin was nailed upon those very church doors. We are afraid it is too true. Some portions of skin, which are pronounced by scientific physiology to be human, have actually been found sticking to the inside of the doors, under the ironwork. It is known that at Hadstock and Copford, in Essex, and it is believed also in Rochester, the skins of Norse pirates were treated in this way by our gentle Saxon forefathers. The nineteenth century has sadly departed from the sentiments and practices of those sweet ages of faith and piety.—*Illustrated London News.*

ARTISTS' HOMES.—NO. 3.

MR. HENRY HOLIDAY'S HOUSE AT HAMPSTEAD.

Oak-tree House is situated in one of the most charming parts of Hampstead. The house has been built about seven years, and Mr. Basil Champneys was the architect, the style being Queen Anne. At the time of its erection it was spoken of with interest by those who were then turning their attention to the square window and red brick class of building which has since become fashionable. The house stands on the steep slope of a hill, and is approached from the east side almost on a level with the first floor or rather studio rooms. This latter expression correctly describes the studio, which forms of course the feature of the planning, as it is substantially divided by running doors from massive girders as shown by the section and the plan into three compartments. The length of the studio, when all three divisions are thrown into one apartment, is about fifty feet. The north end of the studio is really used as the everyday workshop of the painter, where drawings in progress and sculptured figures, with casts from the antique, robed in wet fabrics, for the study of folds and drapery keep an ordinary lay figure company, and form the chief furniture of the compartment, which is chiefly lit by a top skylight. The middle bay or lofty nave-like center, with its gallery on one side, is where Mr. Holiday paints large decorative subjects which require height and an effect of light such as that in which works of this kind are generally intended to be seen, and so a useful purpose was in view when such church like proportions were given to the main compartment of this studio. The roof and joiner's work is painted a very pale green, doubtless with a view of not having too marked a tone of coloring in the room, but from an architectural point of view, the effect in consequence is comparatively poor and commonplace, a result which white of a creamy shade would have avoided. It may be noted that the present lighting is not sufficient, and two more long dormer lights like those existing are to be added. For the purpose of removing the large subjects from the studio, a long thin opening, hung with a door, is provided on the south front, as will be seen on the first floor plan, through which the paintings can be lowered into the garden, and so taken away. The small screened-off part, shown at the south end of the studio, does not now really exist, and this, the third division, is mostly occupied by Mrs. Holiday as a music room, the studio for sound being remarkably perfect. The landing is spacious, and the same may be said of the staircase and hall, the cream-white painting to the woodwork and walls being admirably finished and clean looking. The solid square newels strike one as being suggestive of firmness and strength—an effect often wanting in staircases of houses of this class. The drawing room, with the boudoir beyond, is unquestionably the most pleasing room in the house. There is something so thoroughly simple and home-like about it, a common stone color being used for the wood work, and pale greens, of the quietest tones possible, for the walls. The cosy effect of the bay window, and its Morris drapery covered settees, with their cushions of refined and charmingly designed needlework, the productions of Mrs. Holiday, alone can apologize for the adjectives which they at once, with reason, suggest, as a view is taken through the balustraded and arched opening which divides the boudoir from the drawing room. The dining room is decorated in dark blue, and, like the other rooms in the house, contains some good examples of Chippendale & Adam's furniture. In the recess a cabinet of bookcase proportions stands, and arrests attention as being rather unusual in the treatment of the lower part, having disengaged shafts with Corinthian like caps to the large arched opening. The fireplace is a fine reproduction from an old high hob basket like grate, such as are often seen in old seventeenth century houses, but these high hob stoves are not the most practical things in the world, and those who occupy rooms where they are used often find them of very little service. This is the determination arrived at with regard to the one now described, and its room will be made good by one of the low placed slow combustion grates now more generally used, and, like those already employed in the hall and other rooms of Oak-tree House. The principal entrance is rather singular, and is reached by a long passage or covered way, which is convenient but odd. No doubt it was, to a large extent, the outcome of the peculiarity of the site, but it fails in prepossessing the visitor in favor of the house, as all entrance-ways should do as much as possible. The bare brick walls and continuous steps suggest an ascetic feeling, and in no way assimilate or bespeak the homely and social character of everything beyond the final entrance door. The kitchen and offices are arranged below the studio, and have a well screened kitchen yard, and easily approached tradesman's entrance. Externally, the high, double stack of chimneys is a leading feature, with the arched connection, which forms an opening for the dinner bell. The projecting ironwork may not at first be understood; it really is the monogram of the owner, H. H. The walls are of red brick, and the roofs are of tiles; the deep cove is of creamy white, as it should be, and the windows are divided by good thick window bars, of solid and satisfactory proportions. The dormers are covered with lead, and their cheeks are richly elaborated with ornament in the same material.—*Building News.*

"ARTISTS' HOMES" No. 3. "OAK-TREE HOUSE." HAMPSTEAD · THE · RESIDENCE · OF · Henry · Holiday esq



NEW GALVANIC BATTERIES.

The improvement of batteries is an important branch of electrical progress which ought not to be lost sight of in the prevailing diversion in favor of dynamo-electric machines. The nickel battery of Mr. Thomas Slater is one of the latest novelties, and one of its advantages consists in the fact that the salts of nickel formed during its action are salable products. In this battery a nickel plate is used in combination with a carbon or a platinum plate, the nickel being the oxidized metal, corresponding to zinc in the ordinary Daniell or Leclanché cells. These plates may be employed either in connection with a single liquid or with two or even three liquids separated by a porous diaphragm.

One kind of cell on the three liquid principle is made by taking a cylindrical vessel containing two concentric porous diaphragms, the outer of which is half an inch wider all round than the inner one. In the center diaphragm is placed a plate of nickel, which may be cylindrical and either smooth, crimped, or grooved to give a large oxidizing surface. This plate is immersed in the oxidant, which may be either sulphuric, nitric, or hydrochloric acid diluted with water in the proportion of one part of acid to eight parts of water. The space between the two diaphragms is filled with a solution of sesqui-carbonate of ammonia, and in the outer vessel is placed a solution of sulphate of nickel, or the double sulphate of nickel and ammonia with prisms or plates of carbon plunged in it, or such metal as will take up the deposit of metallic nickel yielded by the decomposition of the nickel solution, after the manner of the copper sulphate in the Daniell cell.

In order to keep the battery in continuous operation by strengthening the oxidant, Mr. Slater arranges two reservoirs, one above the battery and another below it, and both connected with the battery by suitable pipes. The upper reservoir is partially exhausted by an air pump on filling it; and the oxidant flows from it to the cells and thence to the lower reservoir. There it is strengthened by the addition of fresh acid, and returns to the upper reservoir in order to pass to the cell as before. By simply exhausting the air from the upper vessel Mr. Slater is able, through the atmospheric pressure acting on the fluid in the lower reservoir, to cause it to flow into the upper one of itself, and thus he

avoids any spilling or wasting of the excitant; and by means of a stop-cock attached to the upper reservoir, he can at will allow the atmosphere to enter and force the liquid on its way to the cells. This plan is a modification of the "perfluent" arrangement patented by Mr. Staite in 1848 for the production of constant currents.

Another battery, invented by Mr. T. J. Howell, consists of three separate chambers likewise. There is first an outer vessel of glass or earthenware, next a vitreous cylindrical chamber perforated with parallel slots vertically, and termed a separator, then inside that a porous chamber or cell, thus forming the three compartments.

The outer compartment, or that formed by the walls of the outer jar and "separator," contains a rod or plate of carbon, surrounded with ordinary peroxide of manganese and broken pieces of charcoal or graphite, as in the Leclanché battery; but in addition to this there is added a quantity of sulphate of manganese, commercially known as "white manganese." For purposes of transport this chamber may be sealed over with marine glue or pitch, taking care to prevent a vent hole for the escape of the gases generated, as in the ordinary Leclanché.

In the middle compartment, formed by the slotted "separator" and the porous cell, a solution of sulphuric or nitric acid and water is poured. This passes through the slots and permeates the mixture of carbon and manganese in the outer compartment; but the slots are fine enough to prevent the carbon and manganese from passing into the middle cell.

Within the inner cell is placed a rod or plate of zinc provided, like the carbon plate, with suitable binding screws for connecting purposes. This rod is amalgamated with mercury, and a pool of the mercury is left in the bottom of the chamber. To maintain the amalgamation, a solution of hydro-sulphate of ammonia and water is filled in around this plate. Or, instead of placing the sulphuric or nitric acid solution in the middle compartment, it may be placed inside the porous cell, and the solution of hydro-sulphate of ammonia placed in the middle compartment; but the former arrangement is preferred.

Mr. Howell's battery is, it will be seen, a modification of the well-known Leclanché cell; but apart from the novel shape, and the use of the slotted "separator," it differs from the usual Leclanché in employing "white manganese" in combination with the black, a circumstance which is held to keep the connection between the carbon plate and the surrounding packing more perfect than in the case where black manganese alone is used. Another advantage of the arrangement is that the porous cell can be removed for cleansing purposes more readily than when it is embedded in the manganese and carbon fragments. By this means the salts can be washed from the pores of the cell and the internal resistance kept low.

Some years ago Dr. Alexander Muirhead patented a modification of Leclanché's cell in which the porous diaphragm was replaced by a vitreous diaphragm pierced with small holes; but, if we are right, this device did not succeed very well, because of the particles of carbon washed by the solution into the inner chamber, causing a considerable amount of local action on the zinc plate. By the use of the porous diaphragm in addition to the slotted partition Mr. Howell entirely prevents this defect.

A somewhat curious battery has been devised by Colonel Fitz-Charles McCarty, of the Rue Lafitte, Paris. In this cell the positive plate is zinc, and the negative plate is a composition of 20 per cent. by weight of iron filings, 25 per cent. of plumbago, and about 55 per cent. of powdered coke or coal. These three ingredients are well mixed and moulded into proper shape.

The plates are immersed in a liquid composed of about 75 per cent. of salt water by weight (sea water will answer), 3 to 5 per cent. of bichromate of potash, 10 per cent. of vinegar or dilute sulphuric acid, and 10 per cent. of mineral oil—say petroleum. The mineral oil swims on the top, so that when the plates are plunged into the liquid they receive a coating of oil which penetrates the pores, and, according to Colonel McCarty, prevents the hydrogen from entering the latter.

Another bichromate of potash cell is worthy of mention. It is the contrivance of M. Adèle Ergström, of Paris, and consists of two nearly semi-cylindrical cells placed face to face at a little distance apart within a cylindrical vessel of glazed earthenware, which contains the exciting liquid. Each of the semi-cylindrical cells is divided by a partition parallel to its straight face, which face, as well as the partition, the front part of the sides, and the bottom of the cell, is of porous earthenware, the cylindrical back portion behind the partition being glazed, but pierced in the case of the one cell with a number of holes, and in the case of the other cell with a single hole at a high level. The portion of the former cell in front of its partition receives a slab of zinc, and that of the other cell receives a slab of carbon; the spaces in the cells behind the partitions hold the materials for feeding.

The usual materials are employed to excite the battery, namely, bichromate of potash solution and sulphuric acid diluted with water. The bichromate is placed in the feeding compartment behind the zinc, and the acid in the feeding compartment behind the carbon, not quite up to the hole which has been mentioned.

Instead of a slab of zinc granulated zinc may be employed, portions being fed into the cell from time to time as required. In this case a little mercury is placed at the bottom of the cell, and the conducting wire is carried down to the mercury, being insulated where it passes through the zinc lying above the mercury.

For the production of a constant current of moderate strength the elements are placed as above described—the carbon close to the acid and the zinc at a distance from it, and separated by the partition from the bichromate. When a current of considerable strength is required the positions of the zinc and carbon are exchanged, the zinc being thus brought close to the acid. When a weak current of long duration is required, only small portions of the surfaces are made porous. The power of varying the strength of the current at will is one of the special features of this battery.

A more novel battery is, however, that of Mr. Adolph Gutensohn, in which a solution of the sulphate, nitrate, chloride, or chromate of tin is used in the chamber containing the negative plate. Thus pure metallic tin is deposited which may be reduced to ingots by melting in the ordinary way. To insure that, the tin is deposited in a crystalline and not a "spongy" form; the solution should be of considerable strength. One advantage of this battery is that some of the residue of tin mines, now considered waste, may be utilized in forming the negative solution. In this case Mr. Gutensohn prefers to employ chloride of tin. The particular form given to the cell differs little from the ordinary one. An outer jar contains a cylindrical porous chamber. Surrounding the porous chamber is the carbon plate, made in the form of a split cylinder. The solution of chloride of tin filling both compartments of the cell is fed by crystals of the salt contained in the porous chamber, and a deposit of pure tin is formed on the carbon plate.

PLOWING BY ELECTRICITY.

MR. C. FELIX, of Sermaize (Marne), France, has continued his experiments, and at the recent Agricultural Show, held in that town, his apparatus has been shown at work. It consists of the ordinary "Gramme" machine, worked by a semi-portable engine, furnished by Boulet & Co., Faubourg Poissonière, Paris; two coils of wire convey the power to a smaller "Gramme" fixed on a framework of wood, movable on four wheels. This acts as an intermediate motion, and has two broad-faced pulleys, one on each side, 20-inch and 14-inch diameter; these run at a speed, if required, of 800 a minute, the latter driving a six-horse power thrashing machine at a considerable distance from the main power. The 20-inch pulley might be used for driving any other machine if required. The plowing apparatus, which is at work at the same time in the field adjoining, consists of a similar Gramme machine, fixed in a very solid framework of wrought iron, about nine feet long by five feet wide, standing on wheels, three feet six inches diameter in front, and four feet six inches behind. Shafts and a locking gear are also attached. There are two of these at work for plowing, as in Fowler's double tackle. The Gramme has two pulleys, one on each side. These, by friction rollers, work the drum of plowing tackle, round which the steel wire rope is coiled, the drum being in the center of the carriage; the wire escaping from the lower part near the ground, and guided in its course by two flat rollers. The plow is one of Howard's double-furrow, supplied by Mr. Pilter, Paris, and fitted for the purpose. The power was conveyed in an instant from the main power in the show yard by a coil of wire on wooden reels, long enough to reach several fields off. The plow worked cleanly and regularly about seven or eight inches deep. The ground was very hard and uneven, as this part of France is suffering very much from want of rain. One man is required to each machine, and one man to the plow, three in all. The plowing was not very straight, as the people crowded about the plow and on the ropes. The driver could not see where he was going, and directly the plow reached the end of its course it was lowered and returned, the machine being thrown out of gear, and reversed with greatest ease. The machines are also advanced or retired without the least difficulty. When this is done, the friction rollers are detached, and the power conveyed to a chain and notched wheel, which moves the machine rapidly forward as the plowing work progresses. The manager, Mr. Ducret, states it would be just as easy to work a three or four furrow plow as this double, but the holdings being small in this country, it is not necessary. Mr. Felix has a large sugar manufactory at Sermaize, and there may be seen his various machines, worked by electricity. The officials connected with the show, and many others, were present, and the greatest interest was manifested in the trials. Electricity, as a motive power, is only in its infancy, but who can help feeling sanguine for its future?

ON SOME LUMINOUS EFFECTS OF INDUCED CURRENTS.

UP to the present time the movements of electricity have been studied principally on solid bodies rendered movable; in liquids, and, at times, in gases at ordinary pressure. In these different cases cohesion steps in to disturb the electrical phenomena, and we observe only a resultant in which this disturbing cause preponderates. M. R. Coulon, of Rouen, has undertaken experiments with a view to get rid of this cohesion, and for that purpose has confined his operations to

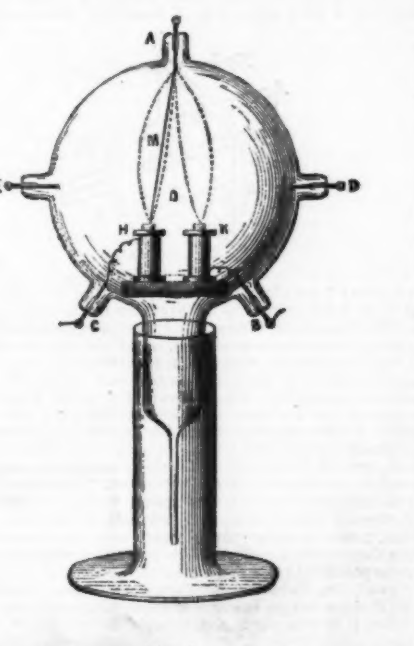


FIG. 1.

highly rarefied gases. He thus has material molecules which are almost free, and which readily obey electrical influences. It is true, however, that, in consequence of this great sensitiveness to external action, a host of causes, which have no action on ordinary currents, have to be eliminated with care.

In his researches on singing condensers, M. Coulon had remarked that the vibrator of a Ruhmkorff coil works differently, according as the two polar wires touch each other or are separated by air. With a Geissler tube, and especially with a sphere, the phenomena cease to be the same when the perfect contact is broken.

Fig. 1 represents a sphere of 7·5 centimeters diameter, exhausted of air, containing a small electro-magnet, weighing 62 grammes, and having a resistance of one telegraphic kilometer. At the top of the globe there is a current conductor soldered into the glass, and on the horizontal diameter, parallel with the two polar surfaces of the magnet, are two other conductors, D and E. The wires of the electro-magnet end at B and C. The apparatus is inclosed by a bell-glass, and the conductors communicate permanently with binding screws, situated outside of the envelope, where the wires of the induction coil are fixed. The contacts are operated at a distance. The induction circuit comprises a pile, a vibrator, and the large wire of the coil. The induced circuit is composed of the small wire of the coil, of the luminous globe, and of a small apparatus (Fig. 2), which

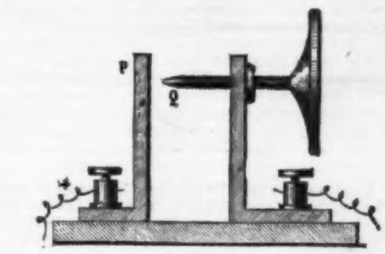


Fig. 2.

allows a perfect contact to be established between P and Q (the distance which is suitable for the production of sparks or tufts), or the complete insulation of P and Q. Let us put A in communication with the negative pole, and B C with the other pole of the coil, and let us be certain of a perfect contact between P and Q. The platinum of the pole, A, is surrounded by a violet sheath, and from H and K shoot toward A two luminous rays, which are slightly stratified and concave toward the center, O. The luminous phenomenon appears concentrated in the triangle, A H K. When one's hand is brought near the globe it produces a scarcely perceptible glimmer. Let us remove the screw, Q, farther from P. The rays, A H, A K, less bright than before, become rectilinear or even convex toward O, according to the length of the spark which jumps between P and Q.

Fig 3.

Let us insulate P from Q by detaching, if need be, one of the conducting wires. A pale light fills the sphere, and, if the luminous fillets appear, they are clearly convex with respect to the center. Let us now cause A to communicate with the positive pole and B and C with the negative. If the contact is perfect we shall see (omitting the other luminous phenomena) two rays directed from A toward H and K, and concave with respect to the center. If the contact is imperfect the rays become convex, while at the same time the electro-magnet becomes luminous. Finally, if the contact is broken, the globe becomes luminous, and when the fillets appear they are convex. The lines, A H, A K, may be considered as extremely mobile conductors, traversed by equal currents and moving in the same direction. Every force acting on the molecule, M, in a direction other than the straight one, A H, will tend to put this line out of shape, and

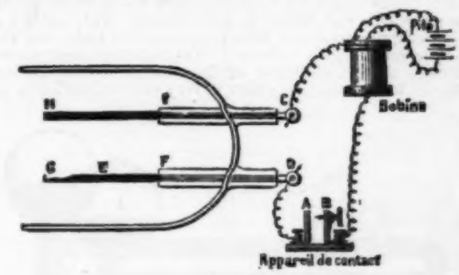


Fig. 4.

the direction of the current will indicate the direction of the force. The attraction between A H and A K will be manifested by concave lines; no action, by straight lines; and repulsion, by convex ones. We see, then, that, in the case of a perfect contact between P and Q, there is attraction; and when, on the contrary, the contact is broken, there is repulsion. We are then led to say that:

In an electrical current the molecules of the conducting bodies attract or repulse each other according to the ratio of the external resistance of the circuit to the internal resistance of the electro-motor.

These conclusions appear to disagree with the laws usually admitted, but they are easily explained by the consideration of molecular movements. M. Coulon, moreover, gives some new experiments in support of them. Into a tube, represented in Fig. 3, he causes a current, bifurcated at A C and B D, to pass, and between the poles there shoot out luminous

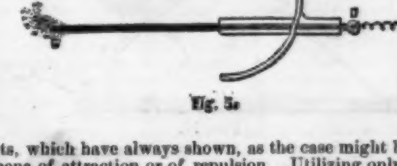


Fig. 5.

fillets, which have always shown, as the case might be, phenomena of attraction or of repulsion. Utilizing only a part of this apparatus (represented in Fig. 4), he causes C to communicate with the negative pole and D with the positive pole of the coil. The two platinum rods, F G and I H, constitute two parallel conductors, separated by a tolerable conductor—rarefied air. That the experiment may be successful, the current must be very weak and just sufficient to

cause the vibrator to operate. With a strong current, the luminous phenomena are too intense, and their variations cannot be followed. Let us separate P from Q (Fig. 2), so that neither spark nor tuft may pass, and we shall perceive faint rays escaping from the extremity, H (Fig. 5), and at G a more diffused light directing itself toward H in the form of an arc. Let us diminish the resistance, P Q, by causing, for example, P to communicate with the ground and put-

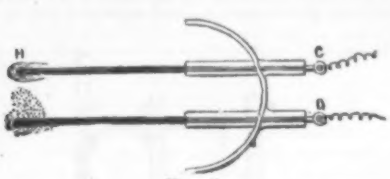


FIG. 6.

ting our hand on Q; then the glimmer increases in intensity and arranges itself as shown in Fig. 6. Let us set up a communication between P and Q by a body having slight conductivity, by powdered charcoal, for instance. The glimmer increases; the rod, C H, is almost completely surrounded by a violet sheath; and, in the positive light, we always observe a dark space, E, between two illuminated places—a very curious and unexplained phenomenon. Finally, on bringing P and Q in contact, we obtain the appear-

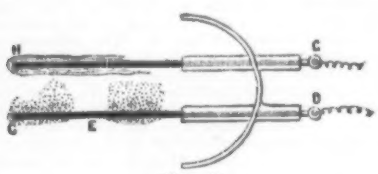


FIG. 7.

ances shown in Fig. 8. The phenomenon exhibits its maximum of intensity at F I, very close to the glass supports; the extremity, G, is dark, and the rod, F G, is luminous only on the side next the other rod. These experiments show us that, in the case of maximum resistance, the current forced back to the ends of the conductors takes on, in traversing the air, a form which still further increases the course that it has to take from H to G.

The repulsion of molecules of electricity of like polarity

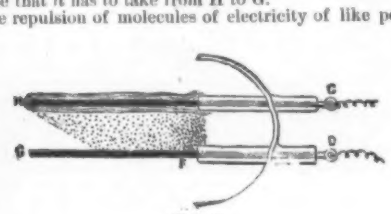


FIG. 8.

over-balances, then, the attraction of molecules of different polarities. It should be remarked that the arc straightens and becomes contracted when the resistance, G H, is increased, and becomes elongated and diffused in the opposite case. There comes a time when the repulsion, which tends to elongate the curve, is found in equilibrium. This position of equilibrium corresponds with the maximum resistance that the current is able to overcome. The last experiment shows, through the accumulation of light on the shortest passage offered to the electric efflux, a very clear attraction in the

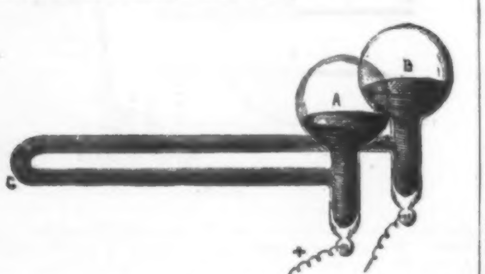


FIG. 9.

case of minimum resistance. If we consider that, in spite of the extreme mobility of the molecules of rarefied gases, the electric current has a well-marked tendency to propagate itself in a straight line (even in cases of repulsion), we shall see that the force developed by the current must be very weak. In order to ascertain what action this force might have on liquid molecules, M. Coulon invented the above remarkable apparatus, which puts in evidence the cohesion

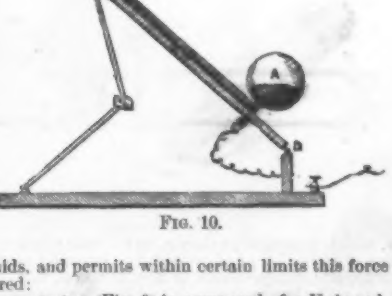


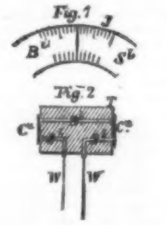
FIG. 10.

in liquids, and permits within certain limits this force to be measured:

The apparatus (Fig. 9) is composed of a U-shaped tube, to the extremities of which are soldered perpendicularly two small bulbs, the necks of which are hermetically sealed and inclose platinum conductors. This tube is fixed on a movable support around a horizontal axis, D, so that it may assume any degree of inclination. It is exhausted of air and filled with mercury, as indicated in Fig. 10. It might be expected that as soon as this tube was inclined the mercury would leave the U-shaped tube and run into the bulbs. In fact, this does happen in most cases, though not always. By a certain manipulation the tube may be made to take a vertical position without the double column of mercury falling. This equilibrium is very unstable, and, to break it, it is only necessary to cause a musical instrument to vibrate in the vicinity. Yet the column may be traversed by a current from a Siemens machine, capable of supplying four electric lights, without separating it. The actions that we have just pointed out in gases, then, are much inferior to the cohesion of mercury, since they do not appreciably alter the degree of it.

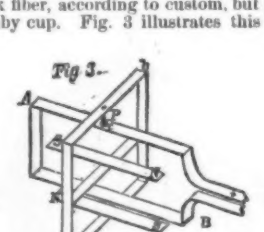
AN IMPROVED THERMO-ELECTRIC APPARATUS.

IT is somewhat singular that while most other instruments of physical research have been greatly perfected, the beautiful invention of Melloni, the thermo-pile, should have been much neglected. To-day, indeed, it is little better than when it left his hands. There are defects in the pile, in the galvanometer, and also in the manner of using the two combined; and it is satisfactory to know that attention has at length been turned toward the improvement of the whole apparatus. Mr. R. H. Ridout, F.C.S., has made a critical study of the thermo-pile in all its parts with a view to eliminate these defects, and the result of his investigation is the improved thermo-pile, which he exhibited and described recently to the Physical Society.



As ordinarily made the thermo-electric metal junctions of the pile are too deep. Fig. 1 represents the usual method of soldering the metals, bismuth (Bi) and antimony (Sb), to form the junction, J, and the consequence is that one side of the junction is hotter than the other, the result being that a local current is set up which short-circuits itself through the junction. Mr. Ridout avoids this waste of energy by placing the bars in a glass tube, T, and constructing the junctions as shown in Fig. 2, where the bismuth (Bi) is connected to the antimony (Sb) by a thin plate of copper (Cu) soldered on. The junction at one side is the cold, while that at the other is the hot; WW are connecting wires. Again, the ordinary bars are too long and give unnecessary resistance, the mass of matter to be heated too great, and the junctions too thin or slender. In the new pile these defects are obviated by making the bars only one-half the old length, and using only a single pair.

The faults of the galvanometer commonly employed are that the space nearest the needles, which is the most effective part, is not utilized by the wire; the needles are not of the best shape, and the suspension is troublesome. Mr. Ridout's remedies consist in forming the wire of a flat ribbon of copper wound on one bobbin brought close to the needles, which are flat oblong bars taken from the same watch-spring and magnetized in the same piece. They are not hung by a silk fiber, according to custom, but pivoted in an agate or a ruby cup. Fig. 3 illustrates this arrangement,

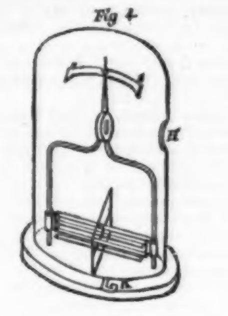


where *a b* is an aluminum frame, A B the flat coil of wire, S N, N S the needles, *p* the pivot, and *c* the cup.

The thermo-pile is frequently used in conjunction with any galvanometer that comes first, or at any rate is available, quite irrespective of the fact that there is a certain form and resistance of the galvanometer coil which will give the greatest sensibility. Clerk-Maxwell gives Sir W. Thomson's equation for the best form to give the coil; and the best effect is also obtained when the internal resistance of the galvanometer is equal to the external resistance of the circuit, provided the ratio of the diameter of the covered wire used to the diameter of the wire when varied, is a constant. Practically understood, this result, which is partly due to Professors Perry and Ayrton and partly to Mr. Oliver Heaviside, means that the galvanometer used in connection with the thermo-pile should have its resistance equal or as nearly so as possible to the resistance of the pile and connecting wires. Mr. Ridout is therefore in the right direction when he designs his galvanometer expressly to suit the pile with which it is to be used, and mounts them both on the same base.

The manipulation of the instrument is also frequently at fault. For example, the different junctions are left exposed to extraneous currents of heat; and the pile and galvanometer are connected to begin with, when in reality they should not be put in circuit with each other until the pile has been exposed for a short time to the source of heat, so as to prevent the current generated itself abstracting heat from the hotter side of the pile, and conveying it to the cooler side, thereby lessening the difference of temperature between the two junctions and lowering the efficiency of the pile.

As constructed by Mr. Browning, the well-known optician, the new instrument is very sensitive and simple. It consists of a single pair of bismuth and antimony bars $\frac{1}{2}$ inch long, and $\frac{1}{16}$ inch thick; the junction being formed by a circular wafer or fish plate of copper about $\frac{1}{100}$ inch thick, and $\frac{3}{8}$ inch in diameter, finely soldered to the ends of the bars. The external surface of the wafer is coated with bichloride of platinum overlaid with lamp-black fixed with very dilute negative varnish of photography to render it highly absorbent of heat. The pile is supported by stout copper terminals above the galvanometer on the same board, as shown in Fig. 4.



The galvanometer consists of a coil wound with 20 turns of copper ribbon insulated with a coat of shellac varnish; and a pair of astatic needles, 1 inch long, and $\frac{1}{8}$ inch wide, made as already described and supported in an aluminum cradle on a fine pivot turning in an agate cup. A contact key, K, is placed at one side and makes the only contact required, that between the pile and coil in the middle of the apparatus.

The whole is inclosed in a glass shade having an aperture, H, at the height of the front of the pile. A glass cone protects the front face of the latter from extraneous radiation, and a glass screen the back face. A directing magnet, N S, placed over the pile, is for adjusting the zero of the needles so as to enable the instrument to be used in any position with respect to the earth's magnetic meridian. In using the apparatus, the source of heat being placed in front of the pile, the glass shade is turned round till the aperture is over against the front face of the pile, and after some 30 seconds' exposure contact is made between the pile and galvanometer by means of the key, and the deflection read off and noted.

So delicate is the apparatus that a distinct deflection was obtained from the radiation of a person standing six feet distant, the temperature of the air being about 12° Fahrenheit. The flame of a common candle affects the galvanometer when placed three feet away. The pile shows that the walls of a room are at different temperatures; and in clear weather the radiation from stellar space is very evident. The new pile is, moreover, very convenient and portable; according to Mr. Ridout it can be got ready for use in about half a minute, while with the ordinary thermo-pile, the preparatory adjustments generally take up as much time as the experiments themselves.—*Engineering.*

CAPILLARITY.*

By GEO. H. STONE, A.M.

BY capillarity is here meant the behavior of liquids when in contact with other substances, not the cause of that behavior. The word is derived from the Latin word *capillus*, a hair, and refers to the small or hair-like tubes in which capillarity is most noticeable.

Projected on the screen you now see the image of a tank partly filled with water. It seems to be wrong side up, and this may confuse you unless you remember that up, here at the tank, means down on the screen. A strip of glass is now let down into the water. The water is drawn up on each side in a concave curve. Some force of attraction seems to draw the water up against the glass. Since the substances are unlike we will call this force "adhesion," being careful not to commit ourselves to any theory as to what adhesion is, or whether it is one force or several forces acting together. When the plate is taken out a drop of water adheres to it, showing that the liquid can wet the solid.

On the screen you now see the images of the edges of two glass plates which are nearly one inch apart. They have been dipped in the tank, and the water rises against them. The curves between the plates nearly meet, but in that little space between the curves the water stands at the same level as outside the plates. By turning a screw these plates are now made to approach each other, and the moment the curves intersect you see that the water between the plates is plainly higher than that outside, and the nearer the plates are brought together, the higher the water rises between them. It has been found that the height to which a liquid will rise in a tube increases in the same proportion as the diameter of the tube decreases.

Floating on the water in the tank are now seen two tapering corks with their smaller ends upward. On bringing them within half an inch of each other they are rapidly drawn together, and now they have each been tipped up so that their tapering sides meet. Evidently here is some active force pulling them together. All small floating bodies, such as saw-dust, are drawn together in the same way. When floating at a distance from other bodies, the water piled up against them pulls equally in all directions, but when they come so near another body that the curves intersect, then more water is being raised on the inside than on the outside, and they are drawn together very much like two wagons if you should bear your weight on a rope connecting them. There may also be a direct pull exerted by the water.

I next let down into the water two thin glass plates fastened to the same block at a distance of about one-eighth of an inch. One is stationary; the other is secured at the top by a hinge of thin sheet rubber, so that it can swing freely. Just the moment they dip into the water the movable plate is drawn toward the other and the water rises rapidly between them. The whole is now plunged under water, and there is apparently no longer any force drawing them together. Plates at this distance apart are drawn together only when the level of the water between them is raised above the general level. But if two flat plates of glass are placed in contact in water it takes considerable force to separate them, which shows that this drawing together of the sides of a capillary cavity exists under water, but the cavity must be small in order to show it. The force with which a liquid draws together the sides of a capillary tube is in some degree an indication of the force with which the liquid is drawn into the tube. This force is very great, as is shown in many ways, noticeably by the fact that dry wooden

* Abstract of a lecture designed to explain the subject experimentally and without resort to the higher mathematics.

wedges, when wet, expand with such force as to split rocks.

Here is a small glass tube of such size that the water rises half an inch in it. If the tube is now depressed until its upper end is only one-fourth of an inch above the water, we see that the water does not attempt to run over; it simply rises to the top, and its upper surface is concave as usual. If now we remove some of the water from the top by a piece of blotting paper, more at once rises to take its place. The particles of the glass which are just above the surface of the liquid seem practically to have the power to draw the liquid upward to themselves, but those at or beneath the surface cannot push the liquid above them. Thus a cap is put over the wick of an alcohol lamp because when the evaporation is stopped no more liquid will be drawn up.

Here is a small glass tube dipped vertically into water, which rises about half an inch in the tube, and will continue at the same level no matter at what angle the tube is held in the water. It is now very oblique, and the water rises three or more times as far lengthwise of the tube as when it was upright, but only to the same vertical height.

Into this full tank is now lowered a bent tube. The water is drawn up around the bend and then horizontally to the end of the tube, where it stops. If the farther end is now lowered the water flows out in drops. The bent tube is in fact a siphon which was filled by capillary attraction.

The last two experiments show that the vertical height to which a column of liquid will rise in a capillary tube does not depend upon the total amount of surface of the two in contact, but rather upon the circumference of the column; in other words, upon the number of molecules of the solid which are attracting the liquid at the upper end of the column. It is just as if horses were harnessed side by side, all being of equal strength and all pulling together. Of course a team containing twice as many horses as another would pull twice as much. In like manner, whether we measure inside of a tube or along the side of a flat piece of glass, twice as many molecules, abreast of each other, will pull up twice as much water. On the screen is now seen an illustration of this. At the left are two parallel glass plates, one-eighth of an inch wide and the same distance apart. At the right are four plates of the same size forming a square tube. You see the water rises between the four plates about twice as high as between the two.

Of two vertical glass tubes suppose the diameter of B is twice that of A. It is a principle of geometry that the circumferences of upright cylinders are as their diameters, and their volumes as the squares of their diameters. Hence the inner circumference of B is twice that of A, and there are twice as many molecules to draw water up the tube, in other words, twice the adhesion. But the weight of water in the two columns, if of equal length, will be as their volumes, or as one to four. If of equal height then there will be in the larger tube twice the attraction in the smaller, pulling up four times the weight, which it cannot do. The water will fall in the larger tube until each molecule of its inner surface is raising the same weight of water as is each molecule of the smaller tube, which will happen when the water is half as high in B as in A. This reasoning would not apply to thin tubes, however, if in such tubes the adhesion should act through the liquid to the other side. In this case the adhesion on each side might mutually strengthen the forces acting upon the other side, and liquids might rise higher in such very thin tubes than the rule here illustrated would allow. Within ordinary limits the law is as stated.

The height to which a liquid will rise in a tube is known to vary according to the nature both of the solid and of the liquid. It is not our purpose now to show which is most concerned in this something which is called adhesion—the air, the water, or the glass; or to investigate the cause of the concave form. To analyze all the various forces at work in these small tubes would be too mathematical for beginners. The net result of these forces is that they act as if there was an attraction between the solid and the liquid, which draws the latter up the tube.

In general it is proved that when a liquid is drawn up into a tube, 1, the liquid can wet the solid, and 2, the surface of the liquid is concave.

It remains for us to study a very different kind of capillary action from that just described. The forces may not be different, but forces which are the stronger in one class of capillary actions are the weaker in the other.

On the screen is the image of a thin tank of mercury. Two plates of glass are now dipped into it; the mercury is depressed between them, and the nearer the plates approach each other the greater is the depression of the mercury. The law of the depression of liquids in small tubes is the same as the law of elevation; the depression is inversely as the diameters of the tubes. You notice that the form of the upper surface of the mercury between the plates is convex, just the opposite of water. On taking the plate out of the mercury it is also evident that the plate is not wet by it.

This depression of mercury in capillary tubes is often called capillary repulsion, or an apparent repulsion. This language seems to imply that there is a repulsion between glass and mercury.

On the screen you now see a projection of a globule of mercury so large as to be flat on top, and resting upon it is a thin sheet of glass. This glass is fastened to a lever so balanced that the glass does not really press down upon the mercury, it simply touches it. If now by lowering the lever the glass is raised, the mercury rises for a time with it and at the same time the globule is drawn in at the sides. Now the mercury falls away from the plate and comes to rest below it. Evidently the glass attracted the mercury and lifted it above its natural level. By this and other experiments of the same kind it is clearly proved that there is a strong attraction and not a repulsion between glass and mercury. Since the use of the term capillary repulsion is liable to mislead, we shall invariably use the term capillary depression instead. In fact, so far as the adhesion between the glass and the mercury is concerned, it tends to draw the mercury up the tube just as it draws up water. If the mercury, then, is depressed, there must be some stronger force in the mercury pulling down its surface. Let us see whether there is such a force.

Here is a familiar object, a half-blown soap bubble. It grows smaller and smaller, and now has disappeared in the pipe. Lighting a tiny taper and blowing another bubble, I present the stem of the pipe to the flame. A current of air is issuing from the stem and blows the flame to one side. What causes this current of air? One of you answers that the air in the bubble was warm as I breathed it out and hence tends to rise. Very well; the bowl of the pipe is now considerably higher than the stem, yet the bubble grows smaller all the time and the current of air issues from the stem as before. Evidently the film is pressing inward with considerable force and driving out the air through the stem.

Here on the table lies a piece of elastic rubber cord. The attractive and repulsive forces between the molecules must be nearly balanced or the cord would be rapidly expanding or contracting. To the eye the ends do not move either way. I take hold of the ends of the cord and pull them apart. I feel the cord now strongly pulling my hands, and on letting go the string flies rapidly back to its original condition. Molecules whose attractive or repulsive forces are not balanced, and which are tending either to fly apart or together, are said to be in a state of tension. It is clear, since the soap film is drawing inward with considerable force, that its molecules are in the same condition as those of the stretched cord, that is, in a state of tension.

Out of the many ways in which it may be proved that a soap film is in a state of tension I will select three simple experiments. Here are two wire rings with handles. One of them is placed closely upon the other and then both are dipped in the soap mixture; they are then taken out together and the films are broken in the center. Now, on pulling the rings apart you see them connected by a film in the form of a cylinder which is much smaller in the center than at the ends. Plainly the particles are in a state of tension and are drawing the film inwards as much as the rings will allow. Next, around the handle of one of the rings is passed a coarse thread. It is now suspended upon the film and hangs loosely across it. If the film on one side of the thread is broken, the thread is pulled quite forcibly to the other side of the ring. By pulling upon the thread the film can be pulled back over the ring, or if the thread is left loose, the end in the hand may be brought around to the other end so as to leave a large vacant loop in the center.

On a film is now placed a piece of thread with a loop tied in it, and then the film inside the loop is broken. Before breaking, the loop was very irregular in shape, but now the film draws outward upon it in every direction, and it takes the form of a nearly true circle. In like manner it can be proved that films of all other liquids are in a state of tension.

Here is a complete soap bubble, and you notice that its form is that of a sphere. Knowing that the bubble is in a state of tension, we at once see that this ought to be its form. The film is tending to shorten as much as possible in every direction, and it compresses the air within into that form in which a given mass of matter will have the least surface possible, which is that of the sphere.

As in these thin films there is practically nothing but surface, we may be sure that the surfaces of liquids are in a state of tension. It remains to inquire whether the interior layers are also in a state of tension.

Upon the water in the tank is now being carefully lowered a piece of wire which has been greased and then rolled in lycopodium powder so that it will not wet. The wire is now lying in a trough on top of the water, but really below the surface of the water on either side. The appearance is just as if there was a thin, flexible layer of ice over the water to hold up the wire. Now waves are being raised and at last the wire breaks through the surface layer and instantly sinks to the bottom. Only the surface layer has power to hold up the wire for a moment. The condition of the interior is in some way quite different from that of the surface.

Here on the screen is the image of a thin layer of water which has been placed in the tank of the vertical lantern. If our reasoning hitherto is correct, then the surface is in a state of tension, and if the tension can be weakened at any place, the film of water will there be broken. Into the water is now being placed a drop of alcohol. See how swiftly the liquid is drawn outward in all directions and stands in a rounded heap about the place where the alcohol was dropped. We now repeat the experiment, using colored sulphuric acid instead. The thin sheet of water breaks as before, and now the acid is traveling outward in curious wriggling forms, which one of your number has compared to a brigade of army worms. Wherever the acid comes it weakens the surface tension and hence is continually drawn outward, always toward those parts where the tension is greatest. When the layer of water in the tank is deeper the whole mass cannot be torn asunder, but the conflicts between the tensions of the different parts of the surface give rise to many curious and beautiful effects. These are well displayed when the essential oils are dropped upon water, as each oil breaks up in its own peculiar way. You now see the "cohesion figures" of the oil of coriander upon water, and next those of cinnamon.

The water in the tank is at present about half an inch deep. A pipette is now plunged quickly into the water and a globule of the solution of creosote is placed on the bottom of the tank. The moment the pipette touched the water a portion of the creosote was drawn violently in all directions, with surprising swiftness, and in a different kind of figure from those already seen. Our interest now centers upon that globule down beneath the water. There is a slight boiling movement going on near its edge and the creosote appears to be drawn off into the water, but notice how slow is the process. It will take more than an hour for even this small globule to be wholly dissolved. I now place beneath the globule a transparent plate or spoon of mica and carefully raise it. Just the moment the upper part of the globule has reached the surface of the water, a part of the creosote is dragged hither and thither in the same rapid way we have already seen, while the rest remains quietly on the spoon. Again raising the globule to the surface you see the whole is whisked away in a few seconds. This shows that the tension of water when in contact with air is far greater than that of the creosote solution, but down in the interior of the water the creosote has for a time the greater tension, enabling it to take the spherical form. By these and similar experiments we are forced to the conclusion that "tension" is far more active near the surface of a liquid than in its interior.

We are next to inquire why a drop is round.

On the screen are the horizontal projections of several drops of mercury of different sizes. All are somewhat flattened, but you see that the small globules are much rounder than the large ones. The largest one has, in fact, been flattened to a level surface all over the top, but near the sides it is rounded. Evidently here are two forces counteracting each other, one tending to make the globule round, and the other is the force of gravity tending to flatten it. What is this force that tends to make globules round, and how does it act?

It is sometimes said in answer to this question, that cohesion acts toward the center, and as all the particles of the drop are drawn with equal forces, the drop will naturally take the form of a sphere. The form of the earth has also been used to illustrate the manner in which a drop becomes round.

Now, according to the law of gravitation, every molecule of matter attracts every other, no matter what may be the distance between them. Very distant molecules, those even which are situated on opposite sides of the earth, are mutually attracting each other toward the center, and all of these attractions can be balanced only when the surface is everywhere at equal distances from the center, at least this would be so if all the particles were free to move. But the gravitation between the molecules of a drop is so feeble, as compared with the attraction of the earth, that the drop would instantly be flattened were there not some other and stronger force acting between the molecules. While gravitation acts at all distances, the molecular forces of cohesion and adhesion act only at distances insensibly small. It is needful now for us to consider how it is that a force which acts only between neighboring molecules and at very small distances can draw distant molecules toward the center.

Here is a bundle of oiled pieces of wire, bound with a pair of broad rubber bands. These bands are strongly stretched, and no matter how flat the bundle is pressed, it instantly becomes nearly round again when it is released from pressure. The molecules of the bands are in state of tension and tend to make the bundle round, because in that shape the distance around it is the least possible. If the stout bands are replaced by weaker ones, the bundle is flattened in the middle, but the ends still remain rounded. This is like the large globules of mercury which we saw a few minutes ago, and the force that tends to make the globules round, evidently acts in the same way as the rubber band: the outer layer of the drop is in a state of tension and tends to shorten in every direction. This outer layer compresses the water within it just as the film of the soap bubble compresses the air. The tendency is to force it into the spherical form, in which shape it will have the least surface possible. As an illustration you see on the screen the image of a large globule of olive oil floating in a mixture of alcohol and water in the tank of the vertical lantern. I now touch the oil with a glass rod and draw out a projecting tongue on one side of the globule. Just the moment the rod is drawn away from the oil this projecting tongue is instantly drawn inward and the drop becomes round again. The experiments already made show that this tension which makes the drop spherical resides chiefly at the surface. It is not cohesion, as it acts in the interior of the drop, but a modification of cohesion that takes place where liquids are brought in contact with other substances.

We are now prepared to attack the problem of capillary depression. When we dip a glass tube into mercury, the upward pressure at the bottom tends to raise the column inside the tube to the same height as the mercury outside. But the whole surface of this inner column of mercury is in a state of tension, both that part in contact with the air and also that in contact with the glass. This tension will compress and pull down the column within the tube until it is balanced by the upward pressure of the liquid. In a large tube the upward pressure is so great that the surface tension cannot depress the whole column and can only pull in the corners. In small tubes the law is that the depression varies inversely as the diameters. Let us see if the doctrine of surface tension will account for this.

Suppose the diameter of a tube, B, to be twice that of A. The circumferences of cylinders are as their diameters and their bases as the squares of their diameters; hence the circumference of the column, B, is twice, while the area of its base is four times that of A. Now the pressures of liquids increase as the depth, the surface tensions as the circumferences of the columns (that is, as the number of attracting molecules abreast of each other), and the upward pressures at equal depths increase as the areas of the bases of the columns. In B, then, twice the surface tension in A is pulling down against four times the upward pressure, and hence is able to depress the column only half as far. The surface tension in one tube is then resisting the same upward pressure as in the other.

We thus see that capillary depression is only an application of the general principle that surface tension tends to force all masses of liquids into the form of a sphere, and it will do so except as it is counteracted by the force of gravity or by the "adhesion" of solids with which the liquids are in contact. The rounding of the edges of a liquid when it is in contact with the solids which it cannot wet, is only a part of this general effort. In fact, a gallon of mercury in a glass dish is only a great drop, flattened by the force of gravity except at the corners.

One other fact ought to be mentioned before closing. In the best barometers by long boiling the film of air which is ordinarily condensed on glass is driven off and the space above the mercury is practically a vacuum. It is then found that the top of the column is flat, showing that there is neither depression nor elevation.

We have not time to discuss what adhesion is, in itself considered, or the cause of surface tension. We can only hint at the cause by saying that Dr. Draper, of New York, and others, have shown that electrical attraction plays an important, perhaps the chief part in the capillary processes.

PRODUCTION OF COLD IN ICE MACHINES.

By TESSIÉ DU MOTAY and AUGUSTE I. ROSSI.

THIS invention relates to the production of cold for the manufacture of ice or for general refrigerating purposes by means of the volatilization of a liquid or liquefied refrigerating agent and condensation thereof again to a liquid state. These operations are performed alternately and continuously, and are carried on in refrigerating, or, as generally called, "ice" machines. Heretofore the refrigerant used, commonly anhydrous sulphurous acid (sulphurous anhydride or sulphurous dioxide) or ammonia, has been condensed by direct pressure, aided more or less by the circulation of a cooling medium. In practical operation, especially with either of the gases named, owing to the great elasticity and tension of their vapor at ordinary or even low temperatures, powerful compression apparatus and hermetically tight receivers of great strength are required in effecting their change from a gaseous to a liquid condition, and *vice versa*, so that the operations may proceed without external loss and in a perfectly continuous manner.

In this invention the power of chemical affinity is made to accomplish work performed by the mechanical compression. In connection with a liquefiable gas or highly volatile liquid an absorbent is used which, at ordinary temperatures, under the proper pressure, is a liquid, and which in that condition, by the force of chemical affinity, absorbs the gas or volatilized liquid and forms therewith a binary liquid. This binary liquid constitutes the refrigerating agent. Volatilization takes place *in vacuo* therefrom, cold being produced, as readily understood, and the binary liquid is reformed at the ordinary temperatures with a comparatively small pressure—viz., that necessary for maintaining the absorbent in a liquid condition, the liquefiable gas being reduced to a liquid by absorption. The pressure heretofore

required to liquefy the refrigerant after volatilization is therefore dispensed with largely, or practically altogether.

It will be readily understood that in operating with a volatile liquid which at a low temperature is gaseous only at less than atmospheric pressure, the advantage resulting from the reduction of pressure required will be less apparent, as in no case is great pressure necessary. It follows, also, from what has been said, that in general the greatest results comparatively are obtained when the difference of pressure required to maintain the absorbent and the absorbed material, gas, or vapor, in a liquid state, independent of each other, is greatest, and, within certain limits, this is true. It is, however, highly important, and indeed essential to the attainment of the best results, that the absorbent should be highly volatile *in vacuo*, even at the lowest temperatures attained in practical operations, and uncongealable under any conditions to which it would be subjected. The latter quality is necessary to prevent the deposition of the absorbent as frost or in icicles, which would greatly impair the effectiveness of the machine. When the absorbent volatilizes its affinity no longer retains the absorbed material in a liquid form, and it also volatilizes, producing cold in the same manner as though from a liquefied state due to pressure, and the volatilization of the absorbent assists in the production.

The best effects are consequently produced with a practically uncongealable and highly volatile liquid as the absorbent, and a gas liquefiable by direct compression only, under great pressure, but reducible to a liquid readily by absorption in the volatile liquid as the absorbed material.

From trial and experiment it is found that sulphuric ether, in conjunction with anhydrous sulphurous acid or ammonia, is most effective and of great practical value. The binary liquid produced by absorption of sulphurous acid or ammonia in sulphuric ether is at ordinary temperatures—say, 80° Fahrenheit or 26·5° Centigrade—and atmospheric pressure homogeneous, and remains unchanged without loss of gas and without tension. It may be kept in ordinary bottles corked, special receivers not being required.

In order more clearly to explain the invention, the manner of carrying the same into effect by means of sulphuric ether and sulphurous acid or ammonia will now be more particularly described.

Sulphuric ether prepared in any ordinary or suitable way—for example, from alcohol and sulphuric acid by distillation—is placed in any desired quantity in a receiver which is connected with a pipe, through which anhydrous sulphurous acid, prepared by burning sulphur or in any known and suitable way and dried over chloride of calcium, is passed into the ether.

Instead of sulphurous acid, anhydrous ammonia, prepared from ammonium chloride (sal-ammoniac) and lime, and dried, may be admitted through the pipe into the liquid; or receptacles containing liquefied sulphurous acid or liquefied ammonia prepared for ice-machines may be connected with the receiver containing the ether, and the gas will force itself by its own elasticity into the absorbing liquid.

The manner of preparing the sulphuric ether and sulphurous acid or ammonia form of themselves no part of this invention.

The pipe conveying the gas should dip below the level of the liquid ether almost to the bottom of the receiver. Suitable means should be used to insure thorough contact to aid the absorption, and the receiver should be kept cool, as by a water circulation. The gas is passed into the ether until the latter is saturated. This can be ascertained readily by the density of the liquid, as when it ceases to increase the saturation is complete.

For practical purposes a sufficient degree of saturation may be obtained in the following way: The sulphuric ether in a concentrated or anhydrous condition—say, fifty to one hundred pounds—is placed in a closed vessel, into which the anhydrous sulphurous acid or ammonia is introduced through a pipe extending to the bottom from a gasometer or other suitable reservoir, by means of which the pressure of a few pounds may be given. The aforesaid vessel is provided with a valve loaded with a few pounds pressure, which, when the operation is completed, is lifted and gives an alarm. Small cocks are provided for withdrawing portions of the liquid as the operation proceeds, and a large cock for drawing off the binary liquid when the operation is finished.

The binary liquid thus produced either with sulphurous acid or ammonia can be stored or sold in ordinary bottles or carboys tightly corked. Care should be taken that it is not exposed to a temperature high enough—say, 90° Fahrenheit, (32° Centigrade), or above—to volatilize the ether, or provision must be made to withstand the pressure generated, which would not, however, be very great.

In order to use and produce cold by the binary liquid a refrigerating or ice machine of any ordinary or suitable construction, containing an aspiration and compression pump, a refrigerating coil or chamber, and a condenser, will answer. For example, what is known as the "Pictet machine" can be used. It is not necessary that the pump and other parts should be constructed with the same strength as heretofore, as much less pressure will have to be resisted in operating in accordance with this invention. The binary liquid is introduced into the apparatus in any suitable way, as by a simple siphon of lead pipe, with proper connections, opening into the refrigerating coil or chamber; or even a funnel would answer. The pump is operated by a steam-engine or other motor. The aspiration produces a vacuum above the liquid, and its two components volatilize together, producing great cold, and pass together through the pump to the condenser, where, under the restored pressure, the ether becomes liquid and reabsorbs the gas, the temperature being kept low by a water-circulation. The pressure required is that necessary to condense the ether vapors—viz., atmospheric pressure, or but little more. The binary liquid reformed in the condenser flows into the refrigerating coil or chamber, and is used again and again.

The proportions of the several parts, the amount of charge, and the speed at which the pump is run to the attainment of the maximum effect, are matters within the discretion of the superintendent.

Certain modifications and improvements to adapt the machine specially to this invention would probably be desirable; but these would form the basis of an additional application for patent.

In working with "ethero-sulphurous dioxide," as the binary liquid produced by absorption of sulphurous acid (sulphurous dioxide) is called, or ethero-ammonia," as that produced with ammonia is named, there is practically no danger from fire. The former hardly takes fire, and the flame is short and fuliginous, and in a limited space can easily be extinguished.

The comparative degrees of cold produced under the same conditions of weight of liquid, velocity, or vaporization, and time, were, for ethero-sulphurous dioxide, a lowering per minute of 24° Fahrenheit, for ethero-ammonia, 22° Fahrenheit, and for ether alone, 15° Fahrenheit.

In practical operation with the same power expended a greater amount of cold can be obtained with the binary liquid not only than that with ether alone, but also than that produced by the vaporization of sulphurous acid or ammonia, both the latter having been liquefied by mechanical compression.

Instead of the gas and liquid named, many others may be used—for example, sulphurous acid in sulphide of carbon, absorption 1 $\frac{1}{10}$ per cent., lowering of temperature 15° Fahrenheit; sulphurous acid in chloroform, absorption five per cent., lowering of temperature 10° Fahrenheit; chloride of methyl in sulphuric ether, absorption less than one per cent., lowering of temperature 18° Fahrenheit, and so on for numberless other absorbents and absorbed materials, liquids, and gases. Chloroform alone would produce a lowering of 5° Fahrenheit. The temperatures given are comparative with those given before.

The proportion to which the absorption of the gases named—sulphurous acid or ammonia, etc.—can be carried is a matter to be determined from experiment, and different results will be often obtained, according to care on the part of the person superintending to push the operation to the point of actual saturation. In different experiments an absorption of sulphurous acid of from thirty-three per cent. to seventy per cent. of the weight of sulphuric ether has been found to take place, the proportion being ascertained by means of the density of the resulting liquids. By more careful experiments a higher rate of absorption might possibly be obtained.

The degree of cold above mentioned for ethero-sulphurous dioxide was obtained with an absorption of thirty-three per cent. of the weight of the ether. With seventy per cent. absorbed the degree of cold produced under the same conditions otherwise would be greater. The proportion of ammonia absorbed was six per cent. of the weight of the sulphuric ether.

We have called the refrigerating agent a "binary liquid." This must be understood of the two components—the absorbent and the absorbed—and not as excluding the idea that either or both the components could be compound—that is, composed of two or more elements, provided they were not antagonistic.

We prefer to saturate the absorbent with the absorbed gas, as the best effects are thereby produced; but it is evident that the same advantages in a less degree could be obtained with less than saturation, or by the use of ether or other absorbent, only in a proportion to produce a partial absorption of the gas in the ice-machine.

When an absorbent is used which is gaseous at ordinary pressure and temperature, it and the gas to be absorbed should be kept under the conditions necessary to retain it in a liquid, and the binary liquid formed would require a receiver of proper strength, or the two components could be introduced as gases into the circulation of the ice-machine, and the binary liquid formed by its operation.

THE LAW OF DISTRIBUTION ACCORDING TO THE ALTITUDE OF THE ATMOSPHERIC SUBSTANCE WHICH ABSORBS THE ULTRA-VIOLET SOLAR RAYS.

By A. CORNU.

THE mass of the absorbent matter at every altitude is proportional to the barometric pressure, and is consequently in a constant relation to the mass of the atmosphere. If the absorption of the ultra-violet rays were due exclusively to the action of the watery vapor, distributed in height according to the experimental law, the increase of the visibility of the solar spectrum would be unity (one-millionth of a millimeter) on the scale of wave-lengths for an increase in height of 286·9 meters. As direct observation shows a quantity three times larger, that is to say, a unity for 868·2 meters, watery vapor cannot be admitted as the sole cause of the absorption of these radiations. It is, on the contrary, very probable that the other elements of the atmosphere, whose proportion is regarded as constant at all heights, have the power of absorbing the highly refrangible radiations. Atmospheric dust, to which several physicists ascribe the greater part of the absorption of the ultra-violet rays, plays only a secondary part. It is very curious that watery vapor, which takes a predominant part in absorbing the less refrangible rays of the spectrum, should not behave in a corresponding manner with the more refrangible rays.

CACHOU DE LAVAL.

WE find in the *Textile de Lyon*, edited by M. Marius Moyret, the following information concerning the *Cachou de Laval*, otherwise known as the patent dye of Croissant and Bretonnière.

Before proceeding further we will describe the preparation of this color, the name of which often causes it to be confounded with the catechu of India, named in French "cachou."

This cachou de Laval, now manufactured largely by the firm of Poirrier, of Paris, is the product of the reaction of sulphuret (sulphide) of sodium at a high temperature upon a great variety of organic matters, such as bran, sawdust, spent dye-woods, rotten oak wood, etc.

It is found in large bruised fragments resembling wood partly carbonized, very porous, of a bluish-black color, and exhaling an odor of sulphureted hydrogen. It is sold in boxes of tin, soldered up, as it attracts moisture very readily from the air. It contains from 1 to 2 per cent. of water, and dissolves very readily in that liquid. Saturated solutions in hot water contain as much as 25 per cent., but beyond that it is suspended rather than dissolved. The solution is strongly alkaline, and the coloring matter is precipitated by all acids as soon as the neutral point has been exceeded, sulphureted hydrogen being given off. The mineral acids also liberate sulphur, which on the application of heat floats upon the surface. The precipitate is a deep brown, and does not readily redissolve in alkalies.

The first attempts were made at printing with this new color, which, like catechu, was fixed without mordant, and by its own affinity for the fiber. The steaming process merely completed the fixation.

Bichromate of potash to the extent of ½ per cent., applied either in a hot or cold solution (more time being required in the latter case) after steaming, rendering the shades faster.

The ungumming (or dunging) process could be performed by means of a weak mineral acid; that the color was fixed very well without being altered even in alkaline baths; that the grays thus produced were able to resist light, acids, and soaping, but that chloride of lime had a destructive influence.

Mordants applied before printing had no influence.

The new color gave better results if combined with catechu, annatto, and even with indigo, than if used alone.

In the *Bulletin de la Société Industrielle de Rouen* for May and June, 1876, we find a report upon the use of this dye upon woolens and mixed goods by M. Hommey. This report is more favorable to the new product than that of M. Glanzmann, which appeared in the journal of the Society for January and February of the same year.

Nevertheless M. Hommey points out that the quantity of alkali which accompanies the coloring matter is a serious obstacle in producing full shades upon woolens, and renders impossible the production of dark maroons and of aniline blacks, the fiber being attacked, and the tone of the black spoiled. The use of acetic acid, or of an acid salt like the bisulphate of potash, serves to correct this excess of alkali.

M. Hommey points out that when the bichromate is used the bath must neither be too hot nor too cold, nor too strong in chrome, as in that case the yellow cast which it gives to the wool makes its shade differ from that of the cotton warps in mixed goods. The cachou de Laval may be used either upon wool or cotton at the heat of 140° Fahr. for weak solutions, and 122° Fahr. for strong ones.

It is used alone for mode grays of a peculiar tone. When modified by acids and chrome it serves for "noisettes" and darker modes.

With metallic salts, like copperas and bluestone, it gives darker grays and varied shades.

Among the uses of cachou de Laval it may be applied to mixed tissues made from woolen rags and waste, and containing cotton, as it dyes both these fibers the same shade.

The solidity of the shades permits them to resist the further operations which they have to undergo.

M. Hommey submitted to the society samples of felt containing 30 per cent. of cotton dyed with this color, and which have perfectly resisted soaping.

Experiments made at Amiens in 1878 prove that this product may be perfectly well applied for dyeing cotton velvets. The pieces dyed, both with and without the addition of Bismarck brown, were perfectly evenly dyed in all parts without stripes or cloudings. They were also unusually supple, which increased their value from 1½d. to 2d. per thirty-nine inches.

We have already stated that cachou de Laval is sold in soldered tins. Care must be taken when a tin has been opened to put on the cover again if the whole of the contents is not required for immediate use, as if moisture penetrates the product is quickly altered.

When the cachou de Laval is in its normal state it dissolves easily and rapidly in hot water, the solution being of a fine dark bottle green. If it has been exposed to moisture it dissolves imperfectly, and the color is brown instead of green. To remedy this inconvenience it is proper to boil the brown solution for a quarter of an hour with a little carbonate of soda, when it turns green and is then fit for dyeing. Still there is nothing like the ware in its natural state, and dyers should be careful to keep the tins well closed.

DYEING COTTON VELVET IN A MECHANICAL BECK.

The cachou de Laval must be dissolved in 35 pints of boiling water. Pour into the dye-beck 87½ pints of water at about 140° Fahr., in which 4 lb. 6 oz. of common salt have been dissolved. Add 17½ pints of the dye liquor (that is the half), and then take the piece from one end to the other. When it is out of the beck upon the roller add the rest of the dye and give it six complete turns, back and forwards. Then withdraw it from the beck and roll it up on the last roller.

It is not well with cachou de Laval to lay the pieces in cuttles, on account of the stripes produced by the oxidizing action of the air. Before the pieces are dyed they must be carefully and equally wetted, because if some parts are less moist than others they will absorb the colors unequally, producing cloudings. When the piece is rolled on the cylinder, so as to avoid the contact of the air, it is let drain a little. It would even be useful to find a method of wringing out the moisture after dyeing. This would have the double advantage of economizing the color and of requiring less ware for the fixing bath which is weakened by the excess of color not adhering to the fiber.

FIXING.

If the water used contains lime it should be acidulated either with sulphuric acid or spirits of salts, so that it may be distinctly sour to the taste. The object of this acid is to neutralize not merely the lime dissolved in the water, but the caustic alkali so abundant in the cachou de Laval. Without this precaution no combination would take place between the coloring matter of the cachou and the metallic oxide of the fixing salt. The bath must not, however, be made too acid, because if the subsequent washings leave any traces of acid in the velvet they will prove injurious in time.

The metallic salt is then dissolved in this acidified water; bluestone if olives and bronzes are intended, and copperas if catechu browns or maroons are required, or muriatic acid if lighter shades are wanted, or any other fixer which may be selected. It is, of course, evident that if muriatic acid is chosen there is no need to acidify the water previously.

Though the cachou de Laval takes on in the cold, it is better to employ lukewarm water; the action is better and quicker.

The fixation, like the dyeing, is done in six turns. Afterwards the pieces may be laid in folds without any inconvenience. Nothing further is needed but to take it to the washing machine and wash it in abundance of water till perfectly purified.

The piece is then fit to undergo all the customary operations for finishing velvets. It has also the remarkable property of completely exhausting color baths (such as magenta and Bismarck brown), into which it is passed to get the desired reflection.

The whole of these operations—dyeing, fixing, and washing—lasts forty-five minutes. Hence, it is easy to judge of the enormous advantage of cachou de Laval in dyeing cotton velvets, both as regards time and labor. This color renders it possible to obtain with the same material a production ten times greater than the sumac process, with a corresponding decrease in labor. Besides, grounding with cachou de Laval gives a solidity and a power of penetration which no other coloring matter possesses.

DYEING COTTON YARN WITH CACHOU DE LAVAL (22 LB.).

Dissolve 17½ oz. to 4 lb. 6 oz. of cachou de Laval, according to the shade intended, in ten times its weight of boiling water, as pure as possible. Avoid hard water both

for dissolving and dyeing. Only dissolve the color as it is wanted, since the solution undergoes changes on standing.

The dye beck must be made up with the smallest possible quantity of water, not more than 87 pints at most for 22 lb. of yarn. Heat to about 140° Fahr., and strain in the coloring solution in several portions. If the whole of the color is added at once it will work uneven on account of its great affinity for the fiber. Add to the beck 17¼ oz. of common salt, or, what is better, of the bisulphite of soda in the proportion of 75 per cent. of the weight of the cachou employed. This proportion must not be exceeded, as the color would otherwise be precipitated. The salt of the bisulphite of soda must not be added till after the introduction of the coloring matter. Dye for twenty to twenty-five minutes. Brighter shades may be obtained by throwing away the flot, and making up a fresh one after each turn, but this involves a waste of color.

FIXING BATH.

On taking out of the dye-bath wash well and enter the cotton in a hot bath of bichromate, containing 10¼ oz. of that salt. After having worked for a few minutes take out and dry.

In place of bichromate, which gives the fastest shades, we may use copperas, bluestone, or simply sulphuric or muriatic acid—7 oz. of the former, or 17 oz. of the latter, to 22 gallons of water.

The shades vary according to the nature of the fixing bath, from a buff to an iron gray.

COMPOUND COLORS.

Besides the various and fast shades which cacnou de Laval produces alone, it contributes to yield an infinite series of others. It serves as a ground and a mordant for aniline colors and for other coloring matters. For certain purposes it may be usefully substituted for sumac and catechu. Cotton dyed with cachou de Laval, if passed into baths of magenta, aniline brown, green, blue, and violet, and extracts of the woods, takes the most varied shades. Great care must be used to wash the cotton dyed in cachou de Laval most thoroughly before it is passed into the baths of the other colors. Most of these dyes are fixed by simple immersion upon cotton grounded with cachou de Laval.

CALICO PRINTING.

It is merely needful to dissolve the color, thicken with starch or gum print, and steam. Chroming afterwards is not necessary.—*Chemical Review.*

TURKEY-RED OILS.

By Dr. GOTTLIEB STEIN.

IF commercial turkey-red oil, containing from 50 to 70 per cent., is treated with an equal volume of a saturated solution of common salt for half an hour, with diligent stirring, and is then let stand for three days, we obtain an oil of about 90 to 92 per cent.

If this latter oil is then again worked up with its own volume of a fresh saturated solution of salt for half an hour in the manner stated above an oil is obtained of about 95 to 97 per cent.

A third similar operation, and letting the mixture settle for eight days, yields an oil of 100 per cent.

The same strength of oil may also be produced in a single operation.

Suppose, for instance, that it has been found by analysis that a sample of turkey-red oil contains:

Actual oil	50
Water	50
	100

But as is well known, 50 parts of water are capable of dissolving 18 parts of common salt.

To a cask of the above quality of oil, containing 100 lb. of the oil, we add therefore an equal measure of a saturated solution of common salt, and besides 18 lb. of dry, solid salt.

The whole is then very thoroughly stirred together, and when all the salt is dissolved, and the mixture has stood for eight days to settle, the turkey-red oil is of the strength of 100 per cent.

Such oil, even when used in proportion to its strength, gives a shade very slightly more on the blue side than the original oil from which it was prepared.—*Muster Zeitung fur Faerberei.*

THE PRODUCTION AND COMMERCE OF LAC.

By P. L. SIMMONDS.

AFTER indigo (the aggregate annual export value of which ranges from £2,000,000 to £3,500,000), another coloring and resinous substance, lac, is of considerable importance, being also attended with much less outlay in the production. The value of the lac products exported from India ranges from £500,000 to £750,000. From the writings of Mr. J. E. O'Conor, Dr. Carter, Dr. Brandis, Mr. G. W. Strettell, Mr. J. McKee, Mr. A. H. Blechynden, Mr. H. A. Crichton, Mr. Baden Powell, and others, we glean a great deal of information as to the production, manufacture, and commerce of lac.

Lac is a resinous incrustation formed on the twigs and branches of various trees by a small insect, the *Coccus lacca*. The trees on which it seems to thrive best are, the koosum (*Schleichera trijuga*), and the pallas or dahk (*Butea frondosa*); but it is also found on various species of *Ficus*, *Zizyphus*, and others. The incrustation formed by the insect is cellular, of a more or less deep red or orange color, semi-transparent, and hard, breaking with a crystalline fracture. The substance is mainly formed by the female insects, which generally largely outnumber the males. Each of the females inhabits a cell, and the incrustation seems intended to serve as a nidus or protection for the ovum, and for the larva after it has been hatched.

The goodness of lac in commercial estimation depends upon the brightness of the color and the thickness of the incrustation. This is sometimes nearly half an inch thick, completely encircling the twig. To obtain lac in its best condition, it should be gathered before the young have eaten their way out through the body of their mother. If the lac gatherer delays until they have effected their exit, the coloring matter is much diminished, and the resin is pierced through at the top. There is but little dye to be obtained from the lac in this condition. As there are two evolutions of the insect in the year, so there are generally also two gatherings, the first being in March, and the second in October. Some people, it is said, dip the lac-covered twigs in hot water to kill the young insects, it being supposed that a large amount of dye is thus secured.

In India, lac occurs in Bengal and Assam (abundantly), the North Western Provinces (sparingly), the Central Provinces (abundantly), the Punjab, Bombay, Sind, and Madras (more or less sparingly), and Burma (abundantly in some places). Lac is also found in some other countries of Southern Asia, viz., Siam, Ceylon, some of the islands of the Eastern Archipelago; and China; Siamese lac being held in high estimation. In India the best lac is obtained from Assam and Burma.

The quantities produced and utilized vary greatly in different provinces, according to circumstances, certain forests being rich in lac, which has hardly been touched, owing to difficulty of access and the cost of carriage to the place of manufacture and port of shipment.

All the districts of the Central Provinces produce lac, but it is particularly abundant in the eastern districts. Large quantities are consumed in the manufacture of bracelets (choories), rings, and beads, and other trinkets, worn as ornaments by women of the poorer classes; but most districts also export it to a greater or less extent. These provinces, at a rough guess, could readily supply some 25,000 tons of stick-lac annually.

The lac insect is as much artificially propagated or as much cultivated as any other raw material for manufacturing purposes. The operation is most simple, consisting merely of cutting off the branch of an old tree, with the insects on it, and placing it on the branch of a fresh tree, over which and the other branches the insects soon spread themselves.

In its raw condition, incrusted round the twigs of the tree on which the insect feeds, lac is called, technically, stick-lac. The twigs are generally, for convenience of transport, brought to market cut up in lengths of two or three inches, and it is probable that a great deal of material is wasted in this process.

The objects of the manufacturer are, first, to separate the resinous incrustation from the wood; second, to free the resin from the coloring matter; third, to convert the resin into what is called shellac; and fourth, to form from the coloring matter cakes of dye known as lac dye. The various qualities of shellac are known by different names and marks, and there is a considerable range in prices from fine orange to livery, garnet, native leaf, and button. The last quality is so named from the lac not being made in sheets, but dropped from a height, so as to solidify into masses.

In Europe, lac is chiefly used in the preparation of varnishes, and by hatters. The body of all the silk hats in common use is rendered stiff and waterproof by the liberal application of a composition of shellac, sandarac, mastic, and other resins, dissolved in alcohol or naphtha. The brim is always imbued more thickly than the body with this varnish. Lac is also extensively used in the manufacture of sealing wax, which is formed of an amalgam of shellac, Venice turpentine, colophony, and coloring matter, the quantity of lac used being equal to that of all the other articles put together. Lac also enters largely into the composition of lithographic ink, and in the preparation of lake, the coloring matter being precipitated by means of alum or oxide of tin.

The great bulk of the export trade in lac is confined to Calcutta, which is the entrepot for all the shellac (except that which is locally used up) manufactured from the raw material supplied from the forests of Bengal, as well as those of Assam, Oudh, the Central Provinces, and Burma. The latter country has lately entered the field as a direct exporter to foreign countries, and the trade of that province will undoubtedly increase. The two largest customers for Indian lac are the United Kingdom and the United States.

The appended figures show the receipts of lac in the last five years, as given in the Board of Trade returns:

*Imports of Lac into the United Kingdom.**

	From India.		Total from all quarters.
	Cwts.	Value.	Cwts.
1874	60,944	£584,647	71,319
1875	80,929	775,070	86,211
1876	93,001	509,546	98,855
1877	95,866	383,130	100,442
1878	76,628	266,478	79,593

There are a few thousand cwts. of lac received from the Straits, and other countries.

The following figures give the total exports and value of lac of all kinds from India:

	Cwts.	Value.
1874–5	76,643	254,011
1875–6	103,538	755,747
1876–7	128,712	536,976
1877–8	104,645	362,084
1878–9	91,423	298,715

The proportion of the lac dye and the resin exported is shown in the following return:†

	Lac.	Lac dye.
	Cwts.	Cwts.
1870–1	48,590	12,500
1871–2	58,368	17,437
1872–3	50,837	10,507
1873–4	65,896	9,902
1874–5	68,264	8,379
1875–6	92,915	10,668
1876–7	109,661	19,051
1877–8	95,075	9,570
1878–9	83,162	8,261

The above figures are for the financial years ending 31st March.

Lac dye is now of very minor importance, both in the eyes of manufacturers and shippers, as compared with shellac. It has always had competitors in cochineal and other dyes, but lately the competition of mineral dyes has become very formidable. These aniline dyes are produced so cheaply and are worked so easily, that they threaten to supersede the use of most vegetable dyes, and it is probable that the prospects of Indian dyes will, before long, require much consideration from the State and all interested in them.

The export duty on lac was, in 1875, 4 per cent., button lac being estimated at a tariff value of £6 10s. the cwt., and shellac at £8. On the 14th July, 1877, the duty was altered to 2s. 6d. per cwt. on button lac, and 2s. on shellac. On the 27th November, 1874, lac dye was removed altogether from the list of duty paying articles. In India, lac dye is mostly used to dye silk, and to some extent it is also employed in the dyeing of leather. It is not much used as a dye for cotton, on account of the expense. It is employed in England for dyeing cloth scarlet, as it yields an equally brilliant color to that produced by cochineal, and one less easily affected by perspiration.

The coloring matter, which amounts to 10 per cent. in stick-lac, is reduced to 5 per cent. in shellac, the dye being carefully extracted.—*Journal of the Society of Arts.*

* Annual statement of the Trade of the United Kingdom. The figures are for the calendar year.

† Annual statement of Trade and Navigation of India.

FINE BLACK, FOR SILK GARMENTS, NOT TO RUB OFF.

IT is admittedly somewhat difficult to dye a fine black, which does not smear, upon silk garments which have been in wear. The following process yields very satisfactory results:

Leave the silk for an hour in a strong, warm soda-bath and brush the dirtiest parts. In case of ribbons, brush the folded parts with a soft brush, rinse, take them through a bath of muriatic acid at 122° Fahr. (what strength?), rinse again, and enter in a bath of nitrate of iron or black liquor at 5¼ Tw. If the garments can be well spread out leave them for an hour without moving. Lift, rinse, and dye in a cold bath of logwood and turmeric. Lift, heat the bath to 167° Tw., re-enter the silk, turn for an hour and rinse.

For 17¼ oz. of silk the quantities are:—

Logwood	8¾ oz. to 14 oz.
Turmeric	1 oz to 2 oz.

After the dyeing follows the process which prevents smearing. The garment is entered in a bath of bleaching liquor till the cotton threads, which hold the different pieces together, begin to look gray. Then lift, rinse, and spread the silk out. Silks dyed in this manner keep their luster and do not show folds.

The bleaching liquor is prepared by adding 17¼ oz. fresh chloride of lime to a pail of cold water, stirring well, and using the clear only.—*Muster Zeitung.*

MANGABEIRA RUBBER.

THE largest quantity and the best quality of rubber has hitherto been imported from the province of Para, Brazil, and although it has long been known that other provinces of that vast empire contained forests of rubber-yielding trees, these have never been taken advantage of owing to the ignorance or supineness of the natives. The inhabitants of the province of Pernambuco are now beginning to realize the vast stores of undeveloped wealth existing in their virgin forests, and rubber is being exported from that province, which may soon rival Para in the extent of its exports of this article. This action is almost entirely due to the exertions of Senhor Joao Fernandez Lopes, who has spared neither time nor money in his endeavors to improve the agriculture of the province, and to develop its vast stores of natural wealth. This gentleman has issued a circular (dated April 26, 1880) calling attention to this important source of wealth, and giving practical instructions for the collection and preparation of the rubber, from which the following is extracted:

"Mangabeira rubber is the most suitable for the springs of railway wagons, tramway cars, and different machines, and for an infinity of other purposes. The process of extracting the milk from the mangabeira tree is very simple and easy. Each person must be provided with fifty or more small tin basins and a small ax. He should make eight oblique cuts, sloping downwards, at a little distance from each other, all round the trunk of the mangabeira, cutting only the bark, and placing immediately below each cut one of the basins, securing these either with adhesive clay or nails. These small basins will collect the milk that exudes from the cuts, and when full, they must be emptied into a larger vessel. This process should be continued during the whole day, and thus three or four bottles of milk may be collected, according to the fertility of the trees. The cuts should not be deep, as the milk is secreted just below the outside bark; and a great number of incisions should not be made on each tree, as these may weaken or kill the trees, which has been the case, in some instances, with the seringueira, the tree from which the Para rubber is obtained.

"The Para rubber is made in the place where the milk is collected, because, in the process of preparation by smoking, there is not time for the milk to be carried to the houses of the collectors; but here we do not prepare the rubber as they do in Para, but make use of the process introduced in the province of Para, in 1860, by Senor Strauss, which, being much simpler, gives admirable results.

"The process is as follows: Put a little powdered alum into a teacup full of water, mixing it well, then put a few spoonfuls of this solution into a vessel in which three bottles of the milk have been placed, properly strained, to clear it from any extraneous matter. Immediately the milk coagulates, which will be in two or three minutes, the rubber must be exposed to the air on sticks and allowed to drain for eight days. After thirty days, it is ready to send to market in cases or barrels. We have tens of leagues of mangabeira trees, and long ago we might have made use of this wealth, according to the opinion of Senhor Joaquino d'Almeida Pinto, an intelligent botanist of this province. The seringueiras planted here grows perfectly, and there is no lack of different milk-giving trees that might be made useful. The province of Para exported last year three million kilogrammes of rubber, valued at six thousand coutos (£600,000.)

PYRENE OIL.

BRITISH CONSUL SEBRIGHT, in a report on the trade of Corfu, refers to the manufacture of pyrene oil, which is obtained from the residuum of the pulp and kernels of olives, after the berries have been submitted to the usual insufficient amount of pressure, by which the oil is extracted in all the olive-producing countries bordering on the Mediterranean. The residuum in question retains from 2 to 4 per cent. of the oil, which for all time preceding the discovery and application of the present method of extracting was wholly lost to commerce. The experiment, at first hazarded on a limited scale, has proved so successful that there are now two manufactories of this product in active operation in the island of Zante; and to the single high-pressure cylinder employed here at the outset, another has since been added, worked by two steam-engines at 30 horse-power, and capable of producing, one year with another, from 700 to 750 tons of oil. As in general a full olive crop is produced only in alternate years, the supply of the necessary material must vary accordingly; but a fairly regular supply is kept up by importation from the other islands, from Greece and Epirus, and even from Italy, where, with the exception of Lucca and Tuscany, the methods employed in the oil manu-

facture remain in a state of almost primitive inefficiency. The people of these countries cling with pertinacity to old habits, even in the teeth of their own immediate interests. In this spirit the peasantry of the island of Corfu persist in using the refuse of their olive mills for fuel, while one of the managers of the pyrene oil works states that he has neglected no opportunity of proving to them that for any given quantity of this substance they may obtain a price adequate to procure a quantity of firewood doubly sufficient for every domestic purpose. Attached to the pyrene oil works is a soap manufactory on a proportionate scale, worked by a steam-engine of 14-horse power, and turning out from 30 to 40 tons of soap monthly, according to the demand. The article thus obtained is equal in its cleansing properties to the best sorts produced from the ordinary oil used in soap manufactories, differing only somewhat in the color, which is of a palish green. An attempt was made two years ago to introduce it into the English markets; but owing to the heavy freights, added to the export and import duties, the prices obtained were not sufficiently renumerative to encourage a renewal of the experiment.

MANUFACTURE OF PLATE-GLASS.

THE Crystal Plate-glass Company's works are located in Jefferson County, Missouri, 30 miles south of St. Louis, on the left bank of the Mississippi River, and are now connected with the Iron Mountain Railway by its own railway, 3½ miles in length. Its factory buildings, says a correspondent of *Engineering News*, are all of brick, and, including two furnace halls, two casting halls, grinding, smoothing, polishing, and packing departments, with boiler-houses, machine-shops, mill and pot rooms, cover an area of four or five acres. It is now operating two Siemens regenerative gas furnaces of 16 pots each, the daily product of which is 3,000 feet of plate-glass, the only kind of glass made at these works. There are now between 400 and 500 names on its monthly pay-roll, representing skilled and unskilled labor, and at least a dozen nationalities.

The product of these works is steadily increasing, with demand throughout the entire country, and the difficulty heretofore has been to make "supply equal the demand."

The plate-glass in the State House at Albany, N.Y.; the Metropolitan Art Museum, N.Y.; Shillito Building, Cincinnati; Barr Building, St. Louis, and United States Custom House, Chicago, and hundreds of other buildings throughout the country, made by this company, has dispelled the idea that plate-glass, equal to the best made anywhere, cannot be made by this company.

Plate-glass consists of silicate of potash or soda, lime, and alumina. The purest and best sand in the world for manufacturing glass is said to be from Lanesborough, Mass., and other portions of Berkshire County. The plate-glass works at Crystal City are located at that point on account of the sand deposits adjacent, and we were informed that these works are now the *only* plate-glass manufactory in operation in this country.

The melted glass, held in crucibles, manufactured in the building, is taken from the Siemens' regenerative-furnace by the "tregs carriage" and wheeled to the "casting-table," which consists of a massive cast-iron slab, on each side of which are ribs, or bars of metal, which keep the glass within proper limits, and by their height determine the thickness of the plate. The melted glass being poured from the crucible or pot in which it was held on to the table, which has previously been freed from all particles of dirt that may have fallen on it, a copper or bronze roller is drawn over it by hand, and almost immediately after the plate is pushed into the annealing oven, where it remains about five days to cool. After trimming off the rough surrounding edges, the plate is subjected to the grinding process; for this purpose it is placed between one large, square table underneath, which is covered with pieces of glass of varying sizes, and two smaller ones above, which all revolve rapidly, while sand and water is supplied by grinding the surface of the plates. By grinding the surface of the plate is removed, but presents a rough appearance, which is removed by the process of smoothing, which is accomplished by the use of a finer and finer quality of emery, with water. At this stage it is somewhat opaque, and this defect disappears after the final process of polishing. This is performed by fixing the plate of glass upon a table by means of plaster of Paris, when the surface is subjected to the action of a series of wooden blocks, covered with felt and attached to a frame, by which they are made to move over the surface of the glass. At the same time a polishing powder, generally a red oxide of iron, is applied, while the friction may be increased by adding weights to the rubbers. After this the plates are subjected to a hand polish and inspection, when they are ready for sale.

ERYTHROXYLON COCA.

By D. F. SHULL.

THE leaves of this plant, a native of South America, resemble those of the tea plant, have an astringent and aromatic taste, and produce a smarting and numbness of the tongue, due to the presence of an alkaloid, *cocaine*.

The leaves are exhausted with alcohol, the coloring matter precipitated with lime, and the filtered solution evaporated to a small bulk; water is then added, and the evaporation continued to expel the alcohol; after adding potassium carbonate, filtering, and saturating the solution with potassium carbonate, the alkaloid may be extracted by agitation with ether. The ethereal solution is decolorized with animal charcoal, and allowed to stand, when cocaine is obtained in colorless prismatic crystals, odorless, and of a bitter taste. It is soluble in alcohol, ether, chloroform, and water, has strong stimulating properties, produces a feeling of intoxication and a smarting and numbness of the tongue. A light brown amorphous substance is also obtained from the leaves, having a strong smell, a sharp burning taste, and an alkaline reaction. It is soluble in alcohol, ether, chloroform, and water. The leaves also contain gum, tannin, wax, and resin.—*Pharm. J. Trans.*

PETROLEUM AND COAL BENZINES.—The crude petroleum, after treatment with sulphuric acid, is fractionated into naphtha, refined petroleum, and petroleum grounds. The naphtha, which forms from 5 to 10 per cent. of the products, is limpid and mobile, boiling at from 50° to 150°, and having the sp. gr. 0·65 to 0·72. It is again fractionated. The most volatile portion is petroleum ether, boiling at 40° to 70°, and having the sp. gr. 0·64 to 0·65. It serves for dissolving fatty matters. The second portion, which distils from 65° to 90°, is gasoline, used for the production of gasoline gas. Petroleum benzine, the third portion, passes over between 90° and 110°, and serves as a solvent. The residue in the still is known as turpentine-substitute.

SYNTHETICAL FORMATION OF FORMIC ACID.

By V. MERZ and J. TIBIRIÇA.

THE authors have investigated the conditions under which the formation of formic acid takes place by the action of carbonic oxide on caustic alkalies. They find that the absorption of this gas by alkalies with production of formic acid takes place at about 200°. In order to saturate the soda completely, it is best to use it as soda-lime, which must be porous. Another essential is that the carbonic oxide must be moist, and further, that the temperature must not be raised above 220°. Above this temperature the formate is decomposed into carbonate and hydrogen. With caustic potash or potash-lime, this secondary decomposition takes place below 220°, and more easily than with soda or soda-lime. Since the absorption of carbonic oxide by soda-lime, when the necessary precautions are taken, takes place very rapidly, the authors think that formic acid might be made on the large scale in this manner.

Experiments made in the hope of obtaining benzoic acid from sodium phenylate and carbonic oxide yielded negative results. Sodium ethylate absorbs carbonic oxide at 200°. The investigation of the products of this reaction is as yet unfinished.

EXPLOSION OF WINE.

By V. WARTHA.

A QUANTITY of Tokay wine, about 6 hectoliters, containing 15 per cent. of alcohol by volume, was being submitted to Pasteur's process. When almost all the wine had passed through the apparatus, a violent explosion took place, shattering the staves of the casks to fragments. It is supposed to have been caused by the ignition of a mixture of alcoholic vapor and atmospheric air contained in the empty part of the cask. He considers that if wine is heated to 70°, the vapors may reach the dangerous limit of 43° (the "flashing-point"), and that when Pasteurizing strong wines they should be refrigerated with ice as they flow from the apparatus.

LINALOES WOOD.

By J. MOELLER.

THE author has obtained a sample of this wood, the ethereal oil of which is at present largely used in perfumery. The wood is extremely light, porous, almost spongy, has a light yellow color, with darker, denser, and harder portions, which are quantitatively very subordinate. The wood is without taste. Its aqueous extracts are almost colorless, and do not contain any trace of tannin. The alcoholic extracts also are but slightly colored, and the author could not succeed in proving the presence of resinous substances with certainty. The examination with the microscope shows, without doubt, that it is only the dense and darker colored portions of the wood which contain the ethereal oil, whilst the specifically lighter and paler colored portions—the chief portion in the sample—contain empty cells. The author has not yet been able to collect evidence as to the origin of the wood, and the mode of distillation and preparation of the oil.—*Dingl. polyt.*

PREDICTION OF CHEMICAL ELEMENTS.

IN awarding the L. Lacaze prize to Boisbaudran, for the discovery of gallium, the committee remark that the new element was not obtained by accident or by any spectroscopic indications. Its discoverer was led, by theory, to seek, in ores of zinc, an element which was required in order to fill a vacancy in his classification. By operating upon 52 kilogrammes (114·64 lb.) of blende he succeeded in obtaining one-hundredth of a milligramme (0·000154 grain) of gallium; in other words, in order to obtain a unit of gallium he was obliged to use five thousand million units of blende. By pursuing his investigations Boisbaudran found that there was a very close agreement between the properties of gallium and those which had been previously announced by Mendelejeff, as belonging to a metal which was required to fill a vacancy in his classification.—*Comptes Rendus.*

LECTURE EXPERIMENT.—This is a description of a simple apparatus to show the liquefaction of such a gas as ethyl chloride, and consists of a tube closed at one end by a stopcock, and connected at the other by means of a stout caoutchouc tube with a reservoir containing mercury, which may be raised or lowered.—*H. Schulze.*

TURKEY-RED OIL SOLUBLE IN WATER.—To 3 kilos. castor oil are added, with constant stirring and in a very thin gradual steam, 650 grms. sulphuric acid at 66° B. A rise of temperature must be carefully avoided. The whole is let stand for twelve hours, diluted with 3½ kilos water, and soda-ash added in small quantities (about 650 grms.) till the mixture no longer reddens litmus. To dissolve the white emulsion thus obtained ammonia is added till a portion dissolves in distilled water. It is then allowed to settle, and the clear liquid drawn off for use. Sodium sulphate is found in crystals at the bottom.—*Schweiz. Gew. Bl.*

REGENERATING THE POTATO.

CAPTAIN MAYNE REID, the well-known writer of books of adventure and travel, has been for the past three years experimenting with seed potatoes from Mexico, the original habitat of the plant, with a view to escaping the blight which has been so disastrous to the potato crop in England and Ireland. He writes to the London *Live Stock Journal*, from his place in Herefordshire, briefly detailing his experience, from which it appears that of eleven different varieties, planted at the same time, in the same soil, and with the same cultivation, the Mexican alone showed not a spot of blight, all the other kinds having been found to be diseased in a greater or less degree. In addition to the immunity from disease, he finds also that while the best of his English seed yielded a crop of but five tons, or considerably less than two hundred bushels, to the acre, the Mexican seed produced over ten tons, without special care in cultivation, many single specimens weighing a pound or even a pound and a half. After being stored through the winter in ordinary field pits, they come out perfectly sound, and appear to improve in quality as the spring advances. As a table potato or for feeding to stock he thinks they have no equal in England, and he proposes that the Government shall take in hand the importation of seed from Mexico or Peru as a preventive of the blight.

"HUMBUGS IN HORTICULTURE."*

By PETER HENDERSON.

THE lifetime experience of any man is too short not to be imposed upon by many of the hundreds of old varieties of fruits, flowers, or vegetables that are sent out annually under new names. Any well-posted nurseryman can easily detect when a Bartlett pear or a Baldwin apple appears under a new name; or a florist, making a specialty of roses, knows, as when some years ago the old Solfataire rose was sent out under the name of "Augusta"—claiming it to be hardy in every State of the Union, and sold as a great bargain at $5 apiece—that the venders thereof were either swindlers or entirely ignorant of the business they had embarked in; or when the confiding market gardener is induced to buy a new and superior cabbage or tomato seed, at $5 an ounce, and finds them identical with the same varieties that he can buy at half that price per pound, he has good reason to come to the conclusion that the man from whom he purchased was either a humbug or else unfitted, from his ignorance, to engage in the business of a seedsman.

But, unfortunately, from the varied nature of these impostures, it is exceedingly difficult to mete out justice to those who, knowingly or otherwise, place such swindles on the horticultural community. For the man who grows fruit trees is as likely to know as little about roses as the man who grows roses is to know about fruit trees, and either is less likely to be posted in the merits of vegetables. So, then, if the partly-experienced horticulturist may be imposed upon in such a way, how safe is the field when the swindler tries his tricks on the general public? The sharp man of the city falls as quickly into the trap of the horticultural swindler as the veriest rustic, because his city experience of the impostures in other matters helps him nothing in this. He may not be much troubled when he sees a bootblack fall off the dock into the river—particularly if his companion plays off the heroic *role*, and plunges in after him to the rescue—he understood it all, for both can swim like ducks, and there was no more danger for the first than for the second, and none for either. A well-stuffed pocket-book snatched from under his feet is an incident that does not in the least arouse his cupidity, for he has long been conversant with the trick of the pocketbook dropper. The mock auctioneer may scream himself hoarse, offering gold watches at $5 a piece, and it hardly elicits a smile of derision. The tears of the benighted orphan in search of his uncles does not bring a dime from his pocket, for he understands it all, together with a score more of the tricks of the great city. But, in the springtime, when his garden instincts begin to bud, and he sees in some window in Broadway flaming representations of fruits and flowers, he falls into the trap and is ready for a spoiler.

Some years ago I had occasion to act as an amateur detective in one of these horticultural swindling shops, the owners of which are now known in New York as the "Blue Rose Men." When I arrived, there were at least a dozen ladies and gentlemen engaged in buying seeds, bulbs, and plants, the flowers and fruits of which were represented by the pictures on the walls: for example, asparagus was shown as having shoots as thick as a broom-handle, the seeds of which were selling rapidly at one cent a piece, warranted to produce a crop in three months from time of sowing; an old lady had just become the possessor of $5 worth, and seemed delighted with her bargain. One of the most attractive pictures on the wall was an immense colored engraving, showing a tree on which strawberries were growing, and as big as oranges. My gaze was attracted to a handsome plate of blue moss roses, of which I modestly asked the price of the plants. The polite Frenchman (who was doing the principal selling for the concern) whisked out from beneath the table three plants representing to be moss roses (which, by the way, were all alike and were all our common prairie rose), and said, "This one he bloom only once; I tell you the truth, so I sell him for two dollar. This one, he be the remontant, he bloom twice—just twice—I sell him for three dollar; but this one, he be the everblooming, perpetual blue moss rose, he bloom all the time, he cheap at $5." I quietly remarked, if it bloomed all the time why was it not blooming now? He looked at me pityingly and said, "My dear sir, you expect too much; these moss rose just come over in the ship from Paris, you take him home and plant him and he bloom right away and he keep on blooming." I did not take him home, but I took the story, something in the shape it is now told, and had it published in one of the leading New York papers, and, in less than a week, the "Blue Rose Men" had pulled up stakes, but, no doubt, to pitch their camp somewhere else, and set their traps for fresh victims. The "Blue Rose Men" are very impartial in their wanderings, and rarely omit a city of any size, beginning usually in New Orleans in January, rounding northward, and ending up with Philadelphia, New York, and Boston through April and May.

These humbugs in horticulture have their comical side. The other year, in passing St. Paul's Church (Broadway), New York, an old negro had squatted on the pavement with a great bundle of plants carefully mossed up, lying alongside of him. On inquiring what they were, he said they were rose bushes—rose bushes having all the attributes wanted in a rose, fragrance, hardiness, and everblooming, and the price but 50 cents apiece. He had got them, he said, from the boss, and was selling them on a commission. The poor darky was only an innocent agent; he, no doubt, believed he was selling rose bushes, but the boss, whoever he might be, undoubtedly knew better, for the plants were not roses at all, but the common cat brier—smilax sarsaparilla—one of the worst pests of our hedgerows, but which is near enough in appearance to a rose to deceive the ordinary city merchant.

That same season at every prominent street corner could be seen the venders of the "alligator plant," which some enterprising genius had cut by the wagon load from the Jersey swamps, and dealt them out to those who retailed them on the street.

The "alligator plant" was sold in lengths of twelve to twenty inches, from 25 to 50 cents apiece, according to its straightness and length; and by the number engaged in the business, hundreds of dollars' worth must have been sold. The "alligator plant" is the rough triangular branches of the sweet gum tree (*Liquidambar styraciflua*), common in most parts of the country. There is no doubt whatever that these pieces of stick have been planted by thousands during the last two years in the gardens in and around New York, with about as much chance of their growing as the fence-pickets.

The bulb peddlers, a class of itinerant swindlers, deserve brief attention. They have always some wonderful novelty

* Essay read at the annual meeting of National Association of Nurserymen and Florists, held at Chicago, June 16, 1880.

in bulbs; and their mode of operating to the uninitiated has a semblance of fairness, as they are liberal fellows, and frankly offer to take one-half cash on delivery, and if the goods do not come up to representation the other half need not be paid—for example, when the gold-banded Japan lily was first introduced, bulbs the size of hickory nuts sold at $250 per 100. About that time one of these worthies came along with samples of a lily of fine size and appearance, with which he told he had just arrived from Japan. There was no doubt of its genuineness, for he had seen it flower. He had a large stock, and would sell at $100 per 100, but he was willing to take half that amount down and the other half when it flowered and had proved correct. It did not prove correct, and he never called. The bulb he sold was the common white lily—*Lilium candidum*—which is sold everywhere at $5 or $6 per 100. These same scamps flood the rural districts every year with blue gladiolus, scarlet tuberoses, and other absurdities in bulbs and seeds, usually on the same terms, of one half cash down, the other half when the *rara avis* has feathered out. It is needless to say they never try it twice on the same victim, but avail themselves of our broad continent, to seek out new fields for their operations.

One of the most successful swindlers of this type was Comanche George, whose fame became national. George made his advent in New York in 1876. He was, he said, a Texas scout, and for years his rifle, revolver, and bowie knife had been the terror of the red man, but one day in his rambles on the lone Texas prairies his eye was arrested by a flower whose wonderful coloring eclipsed the rainbow, and whose delicate perfume was wafted over the Brazos for leagues; in short, never before had eye of mortal rested on such a flower. The man of war was subdued. He betook himself to the peaceful task of gathering the seed, and turned his steps to the haunts of civilized man to distribute it. We first heard of him in Washington, where he wished to place it in the hands of the Government, and accordingly offered it to Mr. William Smith, Superintendent of the Botanic Gardens there, but the Government, so Smith said, was not just then in a position to buy, and with his advice, George trimmed his sails for New York, and a market. His success in Baltimore and Philadelphia was so great (where he started the sale of the seeds at two cents a piece) that it induced him when he struck New York, to advance the price to five cents a seed. He put up at one of the best hotels, and claimed that for a month his sales of the seed of the cockatelle—the beautiful Texas flower—reached $50 a day. But his success threw him off his balance; he took to fire-water, and in an unguarded moment fell into the hands of a newspaper man, who extracted from him all the facts connected with the enterprise—George never was a scout, had never been in Texas, but he had been a good customer to the various seedsmen of the different cities, where his purchases of okra or gumbo-seed, at about 50 cents a pound, had made nearly a dearth of the article. His victims (whose names he gave by the score, and which were duly chronicled in the newspaper article referred to) were from all classes: the enterprising florist, who secretly went into it in a wholesale way, with a view to outwit his less fortunate fellows; the grandee of Fifth avenue, who anticipated a blaze of beauty on his lawn; the hotel man, whose window boxes were to perfume the air; all had fallen easy victims to the wiles of Comanche George. George disappeared from New York, though there is but little doubt that his business had been too successful for him to abandon it. A newspaper paragraph, cut from a paper last week, which reads as follows, looks as if it might be the Texas scout in a somewhat different *role:*

"The prepossessing appearance, gentlemanly demeanor, and foreign accent of the man who called himself Carlo Corella, Botanist to the Court of Brazil, convinced a number of wealthy San Francisco ladies that he was truthful. He said to each that the failure of a remittance compelled him to sell some rare bulbs of Brazilian lilies, which he had intended to present to Mrs. R. B. Hayes. 'The flower,' says the *Chronicle*, 'was to be a great scarlet bell, with ecru ruchings on the petals, a solferino frill around the pistil, and a whole bottle of perfumery in each stamen.' He sold about fifty almost worthless bulbs at $4 each."

The nurserymen present are no doubt better posted in the swindles practiced in their particular department than I am; but operators engage in different lines in different parts of the country: for example, we have never yet seen in the Eastern States any one trying to sell an apple tree bearing blue apples as big as melons, as we were told at our meeting at Cleveland, last year, had been successfully done in Ohio and Illinois. Still, we have men of fair ability in the nursery swindling line, one of whom last winter succeeded in disposing of hundreds of winter-bearing grapes, by carrying with him a few good bunches of the white malaga of the shops.

One great detriment, not only to the florist but to the purchaser, is begotten of these swindles in horticulture. The purchaser of flowers in our markets must have his plants in bloom, because he has been at times so swindled that he must now see what he buys. In New York, the amateur rarely buys from the grower, but from the agent or middleman who sells in the market stands, or street corners. These, whether men or women, are generally entirely ignorant of the nature of plants, and most of them have no responsibility, and they rarely fail to make their wares accord to the wants of the purchaser—nearly every plant is hardy, everblooming, and has all the qualities desired by the buyer.

But now and then these swindles become a serious matter to the victim. Some years ago, a typical Englishman, who had been a greengrocer in Covent Garden Market, London, found his way to New York; he at once discovered an almost entire absence of cauliflowers in our markets, and, what few there were, were sold at prices four times that of London. He soon made up his mind to make his fortune, and, at the same time, show the Yankees something they did not know. He duly selected and prepared the ground for an acre, and one day in May he sallied into the market to procure his cauliflower plants. This he found no difficulty in doing, for at Dutch Peggy's—in those days the headquarters for all kinds of herbs, plants, and seeds—they were to be seen by the wagon load; 10,000 were procured, the quantity for his acre, and, duly planted, they began to grow apace. He had planted 1st of May. If it had been in England, his cauliflower heads would have been ready about the 1st of July; but something was evidently wrong in the Yankee climate. His cauliflower grew through June, through July into August, only to develop into fine specimens of drumhead cabbage, then of hardly the value he had paid for them as cauliflower plants. He got out of the business thoroughly disgusted; and, in telling his sorrowful tale to me a year afterwards, he related that when he went to expostulate with old Peggy about having blasted his prospects, before he could get a word said, she recognized him as a customer, and demanded to know if he did not again want any more early cauliflower plants.

I have said old Peggy was a vender of seeds. It is now something over thirty years ago that a young florist presented himself before her and purchased an ounce of mignonette. Ever alive to business, Peggy asked him if he had tried the new red mignonette; he protested there was no such thing, but Peggy's candid manner persuaded him, and 50 cents was invested. The seed looked familiar, and when it sprouted it looked more familiar; when it bloomed it was far too familiar, for it was red clover. Peggy has long since been gathered to her fathers, and I have entirely forgiven her for selling me the red mignonette.

Perhaps there is no swindling that is more extensively practiced, and which so cruelly injures the operators of the soil, as that of adulteration in fertilizers. The great mass of our farmers and gardeners are poor men, who can ill-afford even to pay for the pure fertilizers necessary to grow their crops, and to pay money and high freights on adulterations worse than useless, is hard indeed. The ignorance of those dealing in such wares does much to spread the evil. A fellow came into my office last summer with samples of a fertilizer, nicely put up in cans, which he claimed could be sold in immense quantities by the seedsmen, as it had not only the wonderful properties of invigorating and stimulating all planted crops, but that it at the same time would kill all noxious weeds.

I need not say that he had waked up the wrong passenger, and that he made a rapid movement towards the door. Yet, notwithstanding the impudence and absurdity of such a claim, the scamp was enabled to prowl around the vicinity of New York for weeks, and, undoubtedly, sold to hundreds.

If he had said he had a cannon from which, when grape shot was fired into a crowd, it killed only enemies—never friends—the one claim would have been as reasonable as the other.

Another species of humbugging which, though it can hardly be called swindling, is somewhat akin to it. I refer to the men who claim to have secrets by which they can accomplish extraordinary results in propagation and culture of plants. I can well remember, in my early days, that the nursery propagator was looked upon as a sort of demi-god, possessing secrets known only to himself and a favored few, whose interest it was to continue to throw dust in the eyes of every young aspirant after knowledge. The door of the propagating house was locked and bolted, as if it were a bastile, and even the proprietor (if he were unfortunate enough not to have practical knowledge) was allowed entrance only as a special favor; for his propagator was an autocrat, of whom he stood in awe and reverence. But, since the advent of horticultural publications in America, particularly during the past fifteen or twenty years, the "secrets" of these pretentious fellows have had such ventilation that now nearly every operation of the greenhouse is as well understood by the tens of thousands engaged in the business as the operation of the farm is by the farmer.

The most of these pretenders to this secret knowledge of horticulture are foreigners, though occasionally a native tries it on. Some fifteen years ago, when the grape-vine mania was at its height, an old Connecticut Yankee pretended he had discovered a new method of propagating the grape, that he would impart for a consideration to the highest bidder; he issued a profusion of handbills to the trade, asking for bids, modestly requesting the receiver of the handbill to hang it up in a conspicuous place.

I sent my copy to my friend Meehan, of the *Gardeners' Monthly*, saying that the pages of that magazine were the most conspicuous place I knew of to comply with the wish of the old gentleman. Mr. Meehan not only inserted the advertisement gratis and in the most conspicuous manner, but he did more, for he appended below the advertisement a few remarks I had ventured to make on the subject. This opened the ball, and for six months the pages of the *Gardeners' Monthly* became the battle-ground for the opinions of the discoverer and myself. But the gratuitous advertisement did not avail him much, for he and his secret soon passed into oblivion, and was heard from no more. There are no secrets in horticulture; the same laws that govern the germination of a seed, the rooting of a cutting, or the taking of a bud or graft, are the same as they were a thousand years ago, and any one pretending to have any secret knowledge in the matter is either an ignoramus or an impostor.

SULPHATE OF IRON AND CRANBERRIES.

THE directors of the New Jersey Agricultural Experiment Station met at Rutgers College Library, May 17. In reporting on the work of the station, Prof. Cook mentioned that on a recent visit to the farm of the late Chalkley Albertson, near Haddonfield, his attention was called to a deposit of "poison marl." This marl destroyed all vegetation when applied in the ordinary way as a top-dressing for crops. He was also informed that piles of the marl which had been lying out and exposed to the weather for some years, were now covered with a luxuriant growth of cranberries. A visit to the locality showed the cranberry plants with the fruit still on them in April, and that the plants were healthy and vigorous. On digging into the earth on which they grew, it was found to be of a rusty red color for four or five inches down, and from that on, downwards, to be dark colored and almost black. It was composed mainly of sand with a very little loam in it. It had a strong inky taste and was decidedly acid to the tongue as well as to chemical tests. Two samples of the earth were taken for analysis, one from near the surface in which the roots of the cranberry were growing, and the other from about 13 inches beneath the surface, and below where any roots were seen. The analyses, which were made only to find the amount of sulphate of iron in the earth, resulted as follow, viz.: Surface earth contains 0·038 per cent. sulphuric acid. Earth, 13 inches down, contains 0·028 per cent. sulphuric acid. This acid is combined with iron, forming the common crystallized green vitriol, or copperas, and what is known to chemists as proto-sulphate of iron and as ferrous-sulphate. The surface layer on an acre contains in the first six inches of depth 1,875 pounds of this ferrous-sulphate, and the lower layer for the same area and thickness contains 1,381 pounds of the same substance. It is quite certain that many of the bogs in which cranberries thrive contain sulphate of iron, and it will be an interesting question for this season, to ascertain whether all the good cranberry bogs are acid from the presence of that substance or from some organic acid. And also to ascertain whether those bogs where the cranberries fail most completely, are not lacking in this acid property.

A soil containing the smallest trace of acid will cause blue litmus paper, if moistened, to turn red the moment the paper touches it. For the purpose of testing the fact as to whether sulphate of iron will cause the cranberry plants to grow more vigorously, it is recommended to make experiments. Take five pounds of sulphate of iron and dissolve it in one hundred gallons of water, and use this in repeated sprinklings on a square rod of cranberry bog. It may be that less than this will be sufficient, and one pound in twenty gallons of water may be used on a square rod, and this be repeated as often as it appears to be needed.

SOUTHERN FARMING.

NOTHING short of a personal visit can give to a New England farmer anything like a clear conception of the wide difference that exists between the farming of his own and that of other sections of the world. Something can be learned by reading, and from the accounts of travelers, but one needs to see for himself in order to fully comprehend the differences that different localities exhibit.

The first thing the New England farmer will miss when he visits the plantations of the South will be the luxuriant green grass for which his own hills and valleys are so noted. In our recent trip through New Jersey, Maryland, and Virginia, although at a season when the difference in the forwardness of vegetation was decidedly noticeable, the trees being at full leaf at one end of the journey and almost as bare as in winter at the other, yet the grass in mowing and pasture appeared to grow thinner and thinner by every hour's travel southward. Of course there were exceptions where special pains had been taken, as in the lawns on some of the public parks, and on the private grounds of some of the more wealthy city residents, but there was none of that fine, thick tuft which one finds so common in New England, by the roadside, and in closely-fed pastures. The cattle, too, although we saw some good ones, generally had the appearance of being of but little account. Very few large herds of good-looking dairy cows were seen south of Philadelphia, indicating that dairying there is a business which is but little understood. At Mt. Vernon, the home of Washington, we found a few good Ayrshire cows that are being well cared for by the present manager, and we saw the spring-house where General Washington's servants kept the milk and butter during the warm, summer weather; but the spring water was not cold, nor did the size of the room indicate that very large quantities of milk were received in it. Indeed, if the statement is true that was made by the superintendent, the room was probably quite ample for the milk of the farm, as we were informed that a letter is now in existence in the handwriting of the General, in which he informs a friend that he has one hundred cows, and yet had to buy a considerable amount of butter to carry the family through the year.

Here, in New England, many of us can remember, without going back many years either, when there was very little income expected from the dairy cows, except during the flush feed of early summer. Manufacturing good dairy products from hay and other cured fodder was scarcely thought of, and we should judge this to be the case to a much greater degree at the South. We found very few buildings that a New England farmer would take for a barn, nor a single farm-house south of Richmond that bore any resemblance to the farm-homesteads that are so common here. Nor do the people seem to understand very clearly what is meant by cultivating a farm. We don't think the word *cultivation* is in their dictionary. Farming there means "cropping" the land; and, judging by the methods employed on the route we traveled, we should judge that the seed is put into the ground with just the smallest amount of plowing possible. We saw fields that were in corn last year, with the stalks still standing in the rows, the ears having been picked off at harvest, and in these same fields we saw men putting in the present year's crop with no other preparation of the soil than what was done with a mule and plow, driven once through the field for each corn row. No wonder that some of the planters who have happened to get hold of Northern papers and books, think the Yankees spend a great amount of labor in fitting a field for planting. We hardly think that this single furrow-farming is considered the best method by the majority of Virginia corn-growers, as we saw other fields where the entire surface was stirred by the plow. Still, the dry weeds that show on most of the fields that were not yet plowed, indicate that the crops are grown with very little cultivation. And even there, the farmers complain that growing crops does not pay, for they say it takes about all the crop to pay expenses, even on land that can be bought for two or three dollars per acre, as we were informed that thousands of acres of it can be.

Grass, such as grows on the Green Mountain slopes of Vermont, or the rich river valleys of other portions of New England, is evidently not at home in much of the Southern soil, yet we have no doubt whatever, that good dairy products can be produced there in abundance by the introduction of a better system of husbandry. We never saw winter wheat look better than on some of these Virginia fields, and we doubt not that wheat, rye, oats, barley, millet, and corn can all be grown and profitably fed to dairy stock, even farther south than our journey extended. And with such crops grown for feeding, we should hope the milk would taste less of the garlic than most of that we were treated with. This garlic weed is a serious pest on the farms from Jersey to Virginia, the best hotels in Washington serving to guests milk tasting of garlic, probably without considering it a matter of much importance.

We have for a long while believed in soiling cows here in New England a part of the year, but if it were our lot to farm in the South, we should adopt the soiling system almost exclusively. Many of our party, judging by the lack of crops, especially of grass, were led to believe that the soil generally at the South is poor, but this is undoubtedly a mistake. Much of it has been terribly run out by constant cropping without putting back any of the fertility that the crops have taken away, but if these lands could be worked as the best farmers in Massachusetts work their lands, we believe the South could be made to "blossom like the rose." The one oasis at Lester manor is sufficient proof of this. Here we found a farm, that a few years ago was no better than the surrounding country, but which is now producing something after the fashion of the market gardens around Boston. Mr. J. B. Davis, the proprietor, has evidently been about the world, and has learned to profit by the example of others. Our stop was much too short, but we were there long enough to learn that peas, tomatoes, sweet corn, asparagus, and small fruits can be produced in perfection. Mr. Davis commenced operations nine years ago, on 2,000 acres, and has now a large portion under cultivation. There are some 9,000 peach trees planted out, most of them of bearing age, though no fruit will be taken this year, the buds being

destroyed by the extremes of heat and cold of the past winter; 4,000 Bartlett pears and 2,000 apple trees complete the list of orchard fruits, while 75 acres are planted to Lawton blackberries, 100 acres to asparagus, 300 to peas, the pods being nearly filled at the time of our visit; 500 acres in tomatoes and 600 in sweet corn. Some of the products may find a market at Richmond during their season, but the main portion of all these fruits and vegetables is preserved in cans and shipped to all parts of the world. During the height of the season, as many as 15,000 three-pound cans are put up daily, ready for shipping.

Mr. Davis employs a large number of colored workmen to whom good wages are paid. His system is so different from anything existing in the vicinity, that the enterprise is still looked upon somewhat in the light of an experiment, but we can see no reason whatever why it should not succeed. In case that a change should seem desirable, the proprietor has laid out his orchards and cultivated fields in such a way that the whole estate may be readily divided up into small homesteads, which, it is presumed, may be purchased, and profitably worked by the intelligent negroes who are now, under Mr. Davis's supervision, acquiring habits of thrift and industry.

We saw more life and activity here, ten times over, than in any other spot out of doors, anywhere south of the gardens which surround and sustain the cities of New York and Philadelphia. The crying want at the South seems to be "capital," but if the people only knew it, they have already just the capital they need, in the native, able-bodied citizens, both white and black, who alone are able, if their efforts are rightly directed, to make the South a perfect garden. Industry, coupled with intelligence, is the sure foundation of success in any country, and the people of the South are beginning to realize the fact and are acting accordingly. One young man, a native of Richmond, who, before the war, was trained to look upon labor as dishonorable to white men, told us that the best thing that ever happened to him was to be taught, through adversity, that honest work was as good for him as for anybody else. With such ideas becoming fixed in the minds of the young men, we can look forward with unbounded hope in the future of the South.—*New England Farmer.*

ACTIVITY OF BEES.

By E. Erlenmeyer and A. V. Planta-Reichenau.

The points to be determined were, whether bees find honey and wax ready formed in flowers or not, and whether they alter, wholly or in part, these substances. Several specimens of honey were examined, and the pollen separated by mixing the honey with water and then filtering, and in the filtrate were determined the coagulable albumen, total nitrogen, ash, and phosphoric acid. Fresh honey appears to contain more water than old honey; the coagulable albumen represents only part of the total nitrogen. Of the remaining nitrogenous matter, a part is soluble in alcohol, a part insoluble; the proportions which these bear to one another are 0·0208 : 0·0337 : 0·0236; the nectar of plants contains no albumen. The amount of wax in honey was determined by means of ether, the extract so obtained being treated with alcohol to remove oils; the purified wax melted at 60° C., and was present in varying quantities: 0·1603 : 0·0357 : 0·0967 part per 100 dry substance. The presence of cane-sugar was microscopically detected, but is present only in small quantities; the greater portion which is at first collected having been changed into glucose by the saliva of the bees, and by the ferment contained in the pollen. The authors consider that the wax is produced by the bees from sugar.—*Biol. Centr.*

ON THE NATURE OF THE PHOSPHORESCENCE OF THE GLOW-WORM.

In some experimental researches, the results of which have lately been published in the *Comptes Rendus* of the French Academy, Mr. Jousset de Bellesme draws the following conclusions: "It is very probable that the phosphorescent substance is a gaseous product, for the structure of the gland, well studied by Owsjanikof, does not give one the idea of an organ secreting liquid. But chemical phosphorescent products at an ordinary temperature are not numerous, which induces one to believe the substance is phosphureted hydrogen. It is for chemists to elucidate this point; but they should seek the matter in the cellular protoplasm and not directly.

"My researches induce me to believe phosphorescence a property of protoplasm, consisting in the disengagement of phosphureted hydrogen. This explains why many of the lower animals, deprived of a nervous system, are phosphorescent. Besides, it offers the advantage of connecting the phenomena of phosphorescence in living beings with that we see in organic matters in a state of decomposition. It is one more example of a phenomenon of the biological order traced to an exclusively chemical cause."

ON A FOURTH STATE OF MATTER.*

By W. Crookes, F.R.S.

In introducing the discussion of Mr. Spottiswoode and Mr. Moulton's paper on the "Sensitive State of Vacuum Discharges," at the meeting of the Royal Society on April 15, Dr. De la Rue, who occupied the chair, good-naturedly challenged me to substantiate my statement that there is such a thing as a fourth or ultra-gaseous state of matter.

I had no time then to enter fully into the subject; nor was I prepared, on the spur of the moment, to marshal all the facts and reasons which have led me to the conclusion. But as I find that many other scientific men besides Dr. De la Rue are in doubt as to whether matter has been shown to exist in a state beyond that of gas, I will now endeavor to substantiate my position.

I will commence by explaining what seems to me to be the constitution of matter in its three states of solid, liquid, and gas.

1. First as to solids: These are composed of discontinuous molecules, separated from each other by a space which is relatively large—possibly enormous—in comparison with the diameter of the central nucleus we call *molecule*. These molecules, themselves built up of *atoms*, are governed by certain forces. Two of these forces I will here refer to—attraction and motion. Attraction when exerted at sensible distances is known as gravitation, but when the distances are molecular it is called *adhesion* and *cohesion*. Attraction appears to be independent of absolute temperature; it increases as the distance between the molecules diminishes; and were there no other counteracting force the result would be a mass of molecules in actual contact, with no molecular movement whatever—a state of things beyond our conception—a state, too, which would probably result in the creation of something that, according to our present views, would not be *matter*.

This force of cohesion is counterbalanced by the movements of individual molecules themselves, movements varying directly with the temperature, increasing and diminishing in amplitude as the temperature rises and falls.

The molecules in solids do not travel from one part to another, but possess adhesion and retain fixity of position about their centers of oscillation. Matter, as we know it, has so high an absolute temperature that the movements of the molecules are large in comparison with their diameter, for the mass must be able to bear a reduction of temperature of nearly 3 0° C. before the amplitude of the molecular excursions would vanish.

The state of solidity, therefore—the state which we are in the habit of considering *par excellence* as that of *matter*—is merely the effect on our senses of the motion of the discrete molecules among themselves.

Solids exist of all consistences, from the hardest metal, the most elastic crystal, down to thinnest jelly. A perfect solid would have no viscosity, *i. e.*, when rendered discontinuous or divided by the forcible passage of a harder solid, it would not close up behind and again become continuous.

In solid bodies the cohesion varies according to some unknown factor, which we call chemical constitution; hence each kind of solid matter requires raising to a different temperature before the oscillating molecules lose their fixed position with reference to one another. At this point, varying in different bodies through a very wide range of temperature, the solid becomes liquid.

2. In liquids the force of cohesion is very much reduced, and the adhesion or the fixity of position of the centers of oscillation of the molecules is destroyed. When artificially heated, the inter-molecular movements increase in proportion as the temperature rises, until at last cohesion is broken down, and the molecules fly off into space with enormous velocities.

Liquids possess the property of viscosity—that is to say, they offer a certain opposition to the passage of solid bodies; at the same time they cannot permanently resist such opposition, however slight, if continuously applied. Liquids vary in consistency from the hard, brittle, apparently solid pitch, to the lightest and most ethereal liquid capable of existing at any particular temperature.

The state of liquidity, therefore, is due to inter-molecular motions of a larger and more tumultuous character than those which characterize the solid state.

3. In gases the molecules fly about in every conceivable direction, with constant collisions and enormous and constantly varying velocities, and their mean free path is sufficiently great to release them from the force of adhesion. Being free to move, the molecules exert pressure in all directions, and were it not for gravitation, they would fly off into space. The gaseous state remains so long as the collisions continue to be almost infinite in number, and of inconceivable irregularity. The state of gaseity, therefore, is pre-eminently a state dependent on collisions. A given space contains millions of millions of molecules in rapid movement in all directions, each molecule having millions of encounters in a second. In such a case, the length of the mean free path of the molecules is exceedingly small compared with the dimensions of the containing vessel, and the properties which constitute the ordinary gaseous state of matter, which depend upon constant collisions, are observed.

What, then, are these molecules? Take a single lone molecule in space. Is it solid, liquid, or gas? Solid it cannot be, because the idea of solidity involves certain properties which are absent in the isolated molecule. In fact, an isolated molecule is an inconceivable entity, whether we try, like Newton, to visualize it as a little hard spherical body, or, with Boscovich and Faraday, to regard it as a center of force, or accept Sir William Thomson's vortex atom. But if the individual molecule is not solid, *a fortiori* it cannot be regarded as a liquid or gas, for these states are even more due to inter-molecular collisions than is the solid state. The individual molecules, therefore, must be classed by themselves in a distinct state or category.

The same reasoning applies to two or to any number of continuous molecules, provided their motion is arrested or controlled, so that no collisions occur between them; and even supposing this aggregation of isolated non-colliding molecules to be bodily transferred from one part of space to another, that kind of movement would not thereby cause this molecular collocation to assume the properties of gas; a molecular wind may still be supposed to consist of isolated molecules in the same way as the discharge from a mitrailleuse consists of isolated bullets.

Matter in the fourth state is the ultimate result of gaseous expansion. By great rarefaction the free path of the molecules is made so long that the hits in a given time may be disregarded in comparison to the misses, in which case the average molecule is allowed to obey its own motions or laws without interference; and if the mean free path is comparable to the dimensions of the containing vessel, the properties which constitute gaseity are reduced to a minimum, and the matter then becomes exalted to an ultra-gaseous state.

But the same condition of things will be produced if by any means we can take a portion of gas, and by some extraneous force infuse order into the apparently disorderly jostling of the molecules in every direction by coercing them into a methodical rectilinear movement. This I have shown to be the case in the phenomena which cause the movements of the radiometer, and I have rendered such motion visible in my later researches on the negative discharge in vacuum tubes. In one case the heated lampblack and in the other the electrically excited negative pole supplies the *force majeure*, which entirely or partially changes into a rectilinear motion the irregular vibration in all directions; and, according to the extent to which this onward movement has replaced the irregular motions which constitute the essence of the gaseous condition, to that extent do I consider that the molecules have assumed the condition of radiant matter.

Between the third and fourth states there is no sharp line of demarkation, any more than there is between the solid and liquid states, or the liquid and gaseous states; they each emerge insensibly one into the other. In the fourth state properties of matter which exist even in the third state are shown *directly*, whereas in the state of gas they are only shown *indirectly*, by viscosity, and so forth.

The ordinary laws of gases are a simplification of the effects arising from the properties of matter in the fourth state; such a simplification is only permissible when the mean length of path is small compared with the dimensions of the vessel. For simplicity's sake we make abstraction of the individual molecules, and feign to our imagination *continuous* matter of which the fundamental properties—such as pressure varying as the density, and so forth—are ascertained by experiment. A gas is nothing more than an assemblage of molecules contemplated from a simplified point of view. When we deal with phenomena in which we are obliged to contemplate the molecules individually, we must not speak of the assemblage as *gas*.

These considerations lead to another and curious speculation. The molecule—intangible, invisible, and hard to be conceived—is the only true *matter*, and that which we call matter is nothing more than the effect upon our senses of the movements of molecules, or, as John Stuart Mill expresses it, "a permanent possibility of sensation." The space covered by the motion of molecules has no more right to be called matter than the air traversed by a rifle bullet can be called lead. From this point of view, then, matter is but a mode of motion; at the absolute zero of temperature the inter-molecular movement would stop, and although *something* retaining the properties of inertia and weight would remain, *matter*, as we know it, would cease to exist.

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